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POPLITEAL ANEURYSMS AS A CAUSE OF PERIPHERAL CIRCULATORY DISEASE: WITH SPECIAL STUDY OF OSCILLOMOGRAPHS AS AN AID TO DIAGNOSIS

FRANK V. THEIS, M.D., CHICAGO, ILL.

(From the Department of Surgery, Presbyterian Hospital, and the Rush Medical College of the University of Chicago)

ANEURYSM of the popliteal artery is a more important etiologic factor in peripheral circulatory disturbances than is commonly recognized. When the sac is small, definite diagnosis is difficult and the symptoms of intermittent or continuous calf pain and coldness of the foot may overshadow the unusual findings in the popliteal space. As a rule the popliteal space is carefully examined only when serious complications are produced by advanced stages of the aneurysm. Arteriovenous aneurysms, however, are more readily diagnosed. The symptoms and physical findings are more pathognomonic than when the artery alone is involved. The present interest in peripheral circulatory diseases has stimulated more thorough examination, including temperature readings,[1] oscillomographs, and differential tests[2] for organic and spastic disease. These studies furnish a more accurate basis for differentiating the causes of peripheral circulatory disturbances.

During the past two years, a series of more than 200 patients suffering with peripheral circulatory disease included 5 cases of aneurysm of the popliteal artery. In all 5 cases, the early symptoms were primarily those of peripheral circulatory disease. In 3 of the 5 cases, the sac was patent and the oscillomographs were sufficiently characteristic to be confirmatory evidence of the presence of an aneurysm. The height of the oscillations at the site of the aneurysm varies inversely according to vasomotor changes in the distal circulation. When the peripheral temperature readings are low, the oscillometer index is

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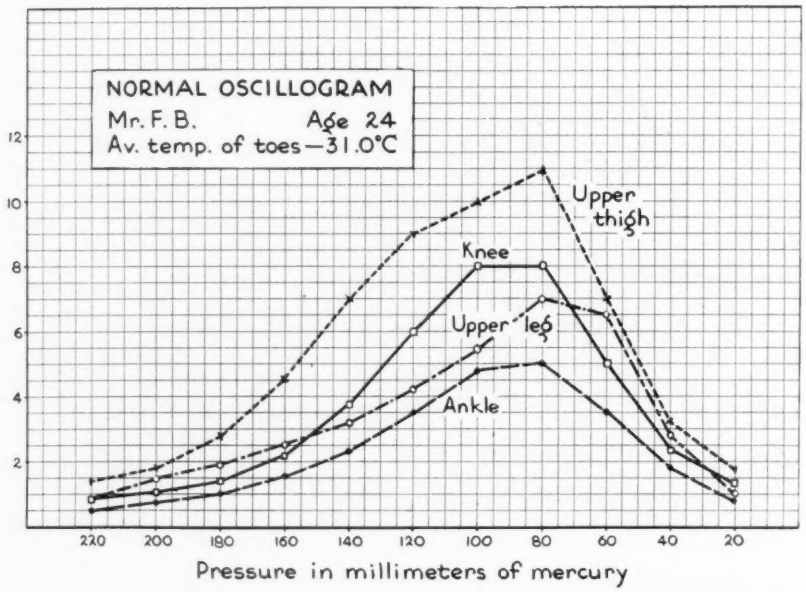

Chart I.—Normal oscillomograph. The curves were made from oscillometric readings obtained from the upper thigh, knee, upper leg, and ankle. Note the distal reduction in the oscillometric index (height of the curve) at the different levels. The average temperature of the toes (stabilized) was 31.0° C.

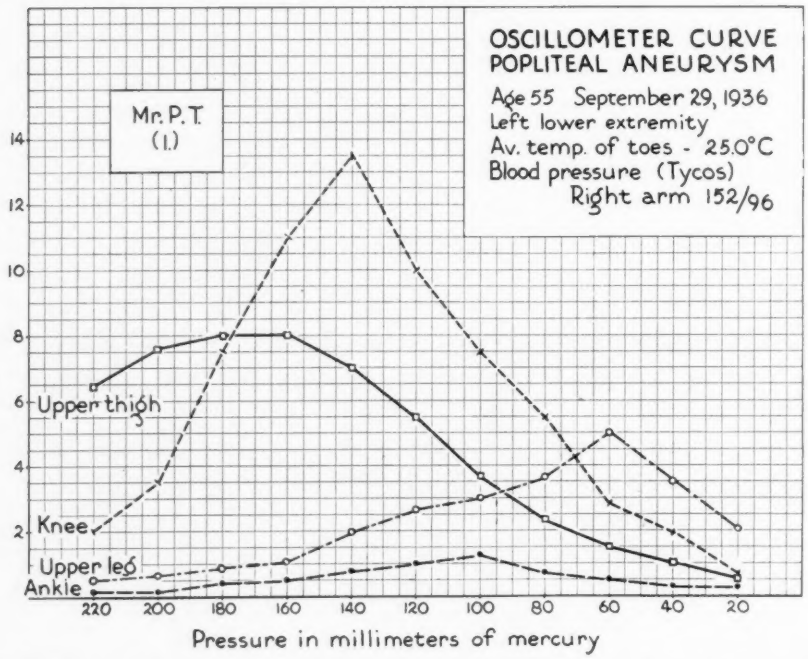

Chart II.—Oscillomograph of popliteal aneurysm described in Case I. An oscillometric index of 13.8 at the knee was obtained when the average temperature of toes was 25° C. Note the relation of the curves from the various levels of the extremity.

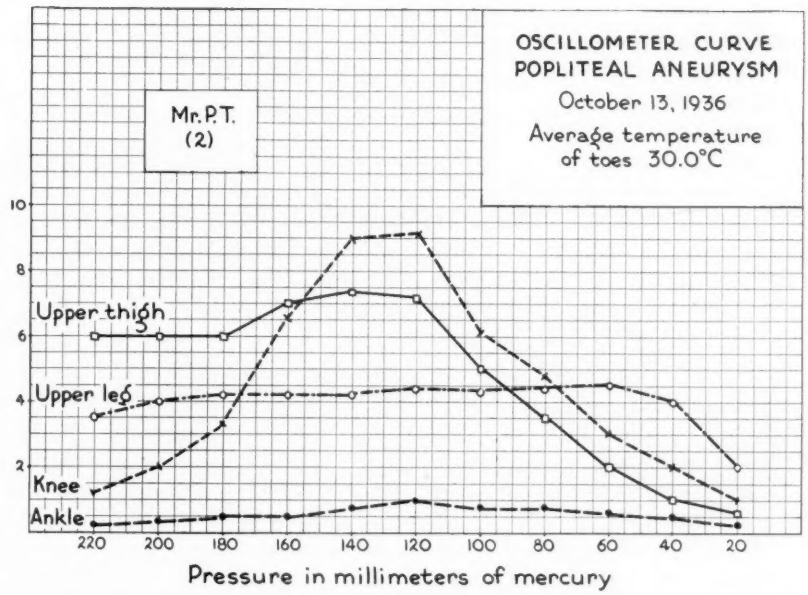

Chart III.—Oscillomographs of same extremity as Chart II (two weeks later) with average temperature of toes of 30.0° C. Note the reduction in the oscillometric index from 13.8 (when the average temperature was 24.0° C.) to 9.1.

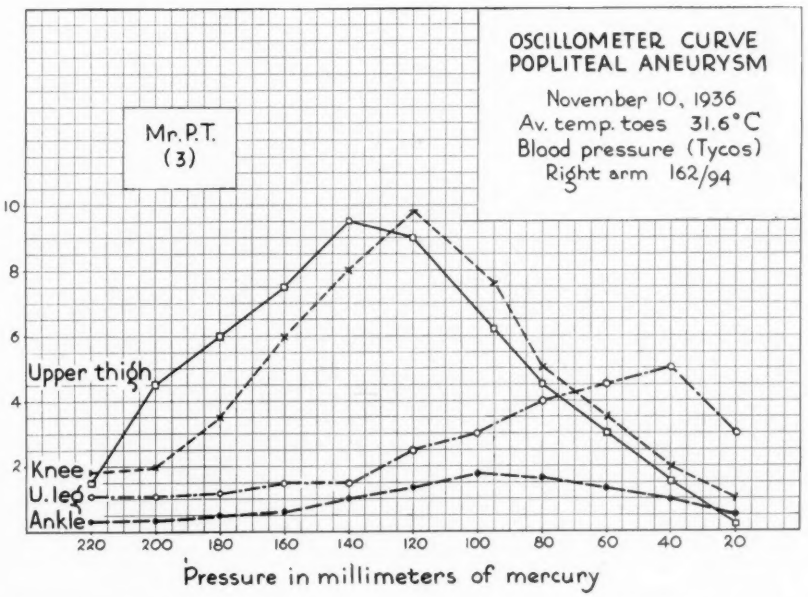

Chart IV.—Same case as Charts II and III with average temperature of 31.6° C. The indices at the upper thigh and knee were both 9.6. With more normal relationship in the height of the curves, the index at ankle has increased also.

high. After return of normal temperature readings, the index is again reduced. These observations suggested a review of all oscillometric records, especially those with undiagnosed causes of peripheral circulatory disease.

REPORT OF FIVE CASES

CASE 1.—Mr. P. T., aged fifty-six years, an engineer, had no symptoms referable to his legs until five years prior to examination. At that time while in a squatting position, working in his garden, he lost his balance. A violent muscle strain at the knee prevented his falling. Simultaneously he suffered severe pain in the back of the left knee. The pain persisted for the remainder of the day but by the next morning had completely disappeared. Periodically, since then, he has suffered disabling attacks of severe cramps in the calf muscles and coldness of the foot. Medical opinion had differed as to the presence of an aneurysm.

On admission to the Presbyterian Hospital, September 29, 1936, a definitely expansile egg-shaped firm tumor was palpable in the lower part of the popliteal space. Peripheral toe temperatures on the left foot averaged 25° C., while on the right foot they averaged 30.2° C. The oscillometer readings (Chart II) were the findings of a popliteal aneurysm. Return of normal peripheral temperatures was accompanied by almost normal oscillometer readings (Charts III and IV). Wassermann test was negative.

On November 16, 1936, after walking rapidly a distance of seven blocks, severe cramps recurred in the left calf muscles. These cramps were so severe that he was completely incapacitated. The foot became cold and the entire leg painful. He had previously experienced the same difficulty when walking hurriedly. The symptoms gradually but completely subsided within one wek. During this period the foot remained cold and the oscillometer index at the knee again showed increased oscillations.

Comment.—This case illustrates the relation of deficient peripheral circulation to the amplitude of oscillations in an aneurysm. With decreased peripheral circulation (evidenced by lower temperature findings, reduced oscillometer index, coldness to touch, and intermittent claudication), the oscillations in the popliteal aneurysmal sac were greatly increased. With improvement in peripheral circulation (decreased peripheral resistance to the flow of blood), oscillations in the aneurysmal sac were again reduced.

CASE 2.—Mr. E., a policeman, aged fifty-two years, had been incapacitated for ten years because of intermittent claudication, continuous rest pains in the calf muscles, and coldness of the feet. The symptoms had become progressively worse until at the time of admission to the Presbyterian Hospital, November 5, 1935, he was only able to walk one block without resting before continuing. Temperatures of the left toes, determined with a thermocouple, averaged 24.6° C., and that of the right toes averaged 24.3° C. Arm blood pressure was 168/110. The oscillometric index at the right knee was 20 (Chart V) and at the left knee 13. With return of normal peripheral temperature readings (30.6° C.) the index at right knee was 13 (Chart VI). As the peripheral circulation was again reduced (temperature readings of 27° C.) the oscillometric index at the knee rose to 16. A definitely expansile tumor was palpable in each popliteal space. Repeated Wassermann tests were negative.

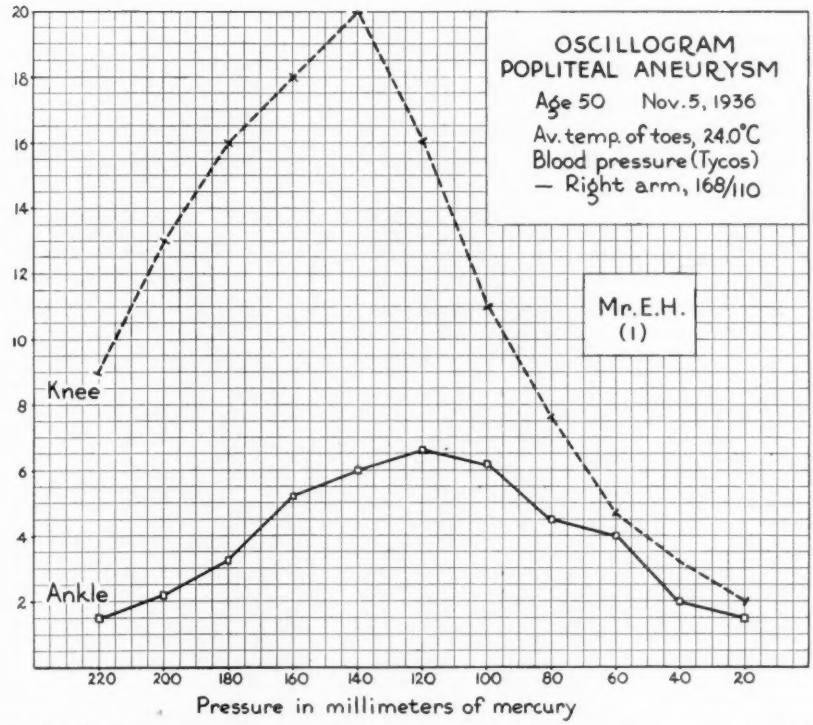

Chart V.—Oscillomograph of Case 2. An index of 20 at the knee was obtained when the average temperature of toes was 24.0° C.

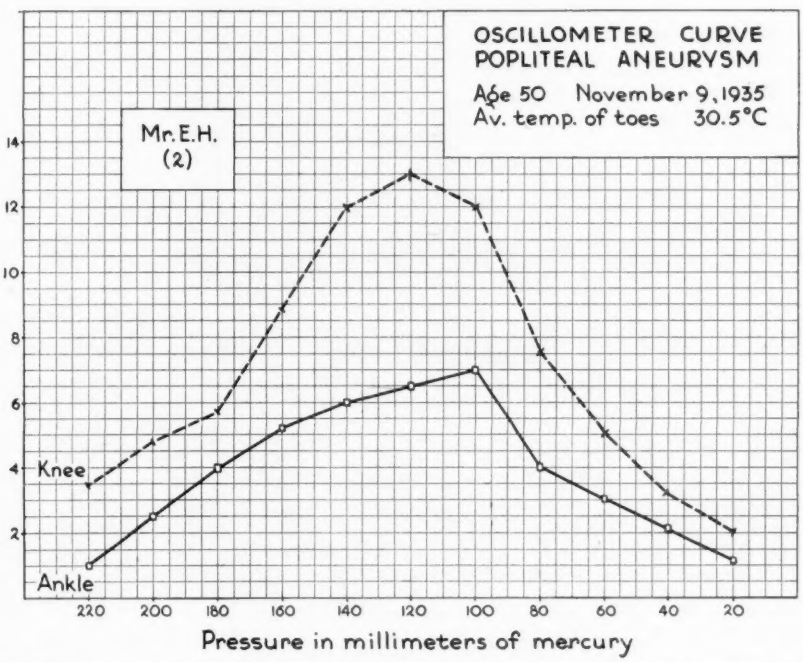

Chart VI.—Same case as Chart V showing an index of 13, when the average temperature of toes was 30.5° C.

Comment.—The relation of peripheral circulation to the oscillometric index at the knee is again illustrated. With each recurrence of deficient circulation in the toes, the oscillometer readings in the popliteal space were increased. Normal peripheral circulation was accompanied by a marked reduction in oscillations. No thrombosis or pressure symptoms occurred.

CASE 3.—Mr. A. L., aged sixty-one years, a clerk, had symptoms of intermittent claudication for about six years prior to admission January 23, 1935. Cramps in both legs became progressively more disabling until as much as five minutes' complete rest was required after walking one city block. Three months previous to ex-

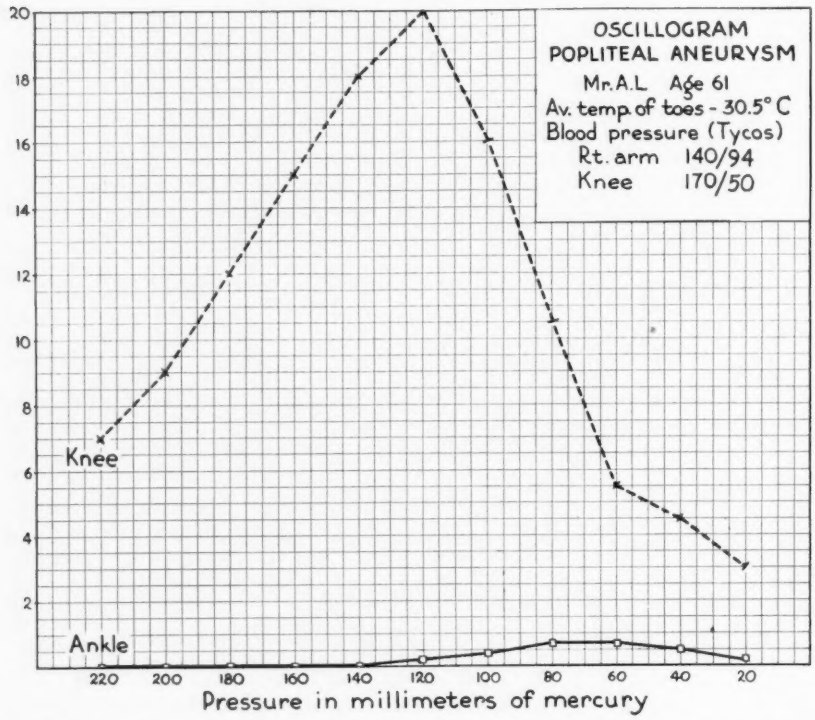

Chart VII.—Oscillomograph of popliteal aneurysm described in Case 3. The average temperature of the toes of 30.5° C. (stabilized for 1 hour in temperature-controlled room at 20° C.) with almost zero oscillometric index at the ankle indicated the adequacy of collateral circulation. At the level of the aneurysm the oscillometer index was 20.

amination while he was sitting at home he developed a sudden excruciating pain in the right leg and foot. The foot immediately became cold, pale, and continuously painful. All peripheral arterial pulsations were absent. Gradually the toes became gangrenous and infected which necessitated amputation. Thigh and ankle oscillometer readings were zero. Wassermann test was negative.

The peripheral temperature readings on the left leg at the time of the initial examination were almost normal. The average temperature of the toes in a temperature-controlled room at 20° C. was 30.6° C. In spite of these findings, intermittent claudication had been as severe as in the right leg for more than six years. Oscillometric index at the knee was 20 and at the ankle 0 (Chart VII).

Examination of the left popliteal space revealed an egg-sized, soft expansile swelling. Arm blood pressure was 140/90. Blood pressure (Tycos sphygmomanometer) at the knee was 170/50 and the oscillometric index was 20. While convalescing from the right leg amputation, the swelling in the left popliteal space gradually became hard and pulsations ceased. The foot rapidly became gangrenous.

Comment.—The aneurysm of the left popliteal artery produced symptoms of peripheral circulatory disease for six years. Although unrecognized until the oscillometer readings suggested its presence,

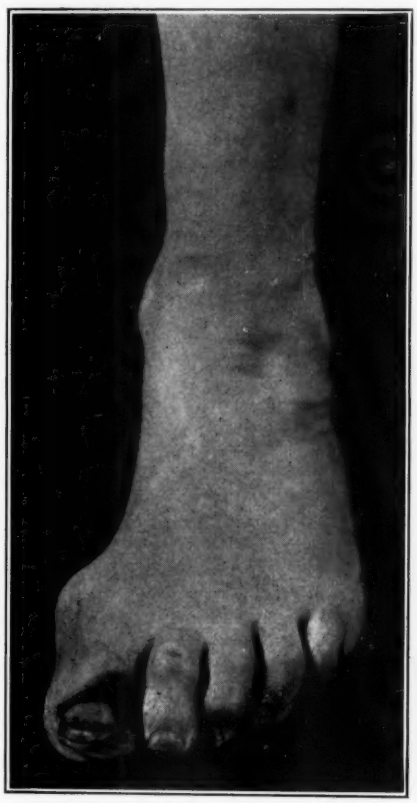

Fig. 1.—Small area of infected gangrene at base of first toe nail described in Case 4. Although symptoms of far-advanced peripheral circulatory disease were present for months, gangrene did not develop until infection set in after cutting the toe nail. The two popliteal aneurysms and the popliteal artery (Fig. 2) were completely thrombosed.

thrombosis with acute circulatory deficiency did not occur until amputation of the right leg required prolonged convalescence.

CASE 4.—Mr. O. T., aged eighty years, was referred September 22, 1936, with severe senile arteriosclerotic circulatory disease of the left foot. There was a small area of infected gangrene at the base of the first toe nail (Fig. 1), and the entire dorsum of the foot and all the toes were discolored and painful. Extreme continuous rest pains had been present for only two weeks, but limitation in walking because of calf pains and coldness of the foot had been troublesome for some months. While taking a long walk three months previously, he developed an unusually severe attack of pain in the calf of the left leg. From this time on deep blue red,

dependent discoloration of the foot and toes, coldness of the extremity, rest pains, and intermittent claudication became progressively more severe. Although the disease was far advanced, he still continued to be moderately active until his admission to the Presbyterian Hospital.

On admission to the hospital there was complete absence of pulsation in the dorsalis pedis, posterior tibial, and popliteal artery on the left side. Good pulsation was present in the femoral artery. The oscillometer readings were zero at the ankle and 1.5 at the knee. In the dependent position the toes and foot were a deep blue red and cold. With the leg elevated the deep discoloration of the foot quickly

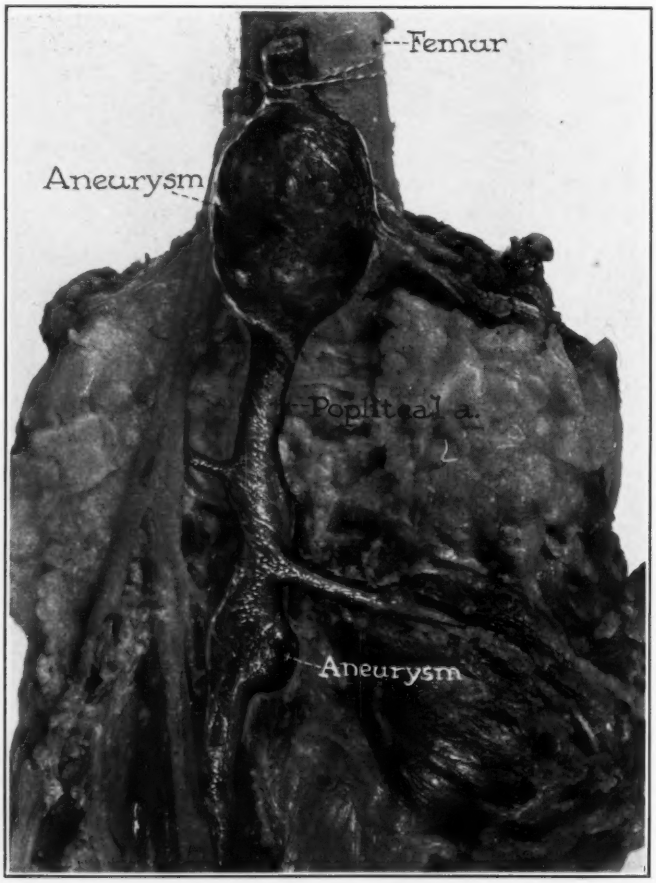

Fig. 2.—Photograph of dissected popliteal space from amputation specimen shown in Fig. 1. Note the two aneurysms and the enlarged collateral arteries.

disappeared, but a bright red hyperemic flush persisted. The surface temperatures of the toes and foot averaged 27.5° C., while on the right foot the average was 30° C. X-ray examination revealed moderate sclerosis of the vessels of both legs. Mouth temperature fluctuated between 99° F. and 100° F. Wassermann test was negative.

Because of the infected gangrene, cellulitis of the foot, and condition of the peripheral circulation, midthigh amputation was performed September 24, 1936. Examination of the operative specimen revealed two saccular popliteal aneurysms (Fig. 2) with laminated thrombi and a thrombus in the popliteal artery which

extended for about 1 cm. into the femoral artery. The posterior and anterior tibial arteries were slightly sclerosed but not thrombosed.

Comment.—Complete occlusion of the aneurysms and popliteal artery did not produce extensive gangrene. It is probable that the intermittent claudication and coldness of the foot which existed for some months were due to the patent aneurysms. The onset of continuous severe pain in the foot occurred at the time of infection. In spite of the patient's advanced age he was not totally disabled by either the aneurysms or thrombosis of the popliteal artery. With the popliteal artery completely occluded, the oscillometric reading at the knee of 1.5 was evidence of the slowness of the arterial occlusion which permitted time for the collateral arteries to enlarge.

CASE 5.—Mr. A., aged forty-six years, a contractor, had received intensive antisyphilitic treatment some years previously but otherwise enjoyed good health. Fifteen months prior to examination, he tripped while bowling. Following extreme muscular effort to prevent falling, a severe pain immediately developed in the back of the right knee. This persisted for a few days and completely disappeared so that he continued his normal daily activity without discomfort or disability. Three months previous to examination (one year after initial injury) without warning the leg suddenly became cold, pale, and painful. Severe cramps occurred in the calf muscles especially when attempting to walk rapidly (intermittent claudication). At no time had he been completely incapacitated. A hard, egg-sized, nonpulsating tumor mass was palpated in the right popliteal space. There was complete absence of pulsation in the popliteal, posterior tibial, and anterior tibial arteries and coldness of the foot and leg.

On October 6, 1936, the right foot and leg appeared no different than the left. However, a hard, nonpulsating swelling was palpable in the right popliteal space and peripheral pulsations were absent, while on the left side all pulsations were palpable. The oscillometric index at the right ankle was almost zero. In the thigh above the tumor an index of 12 was recorded. All readings on the opposite side were increased above normal with 13.5 at the level of the lower thigh. Surface temperatures: 27.5° C. on the right side and 26.4° C. on the left side. Considerable subjective improvement followed elevation of skin temperatures under treatment.

Comment.—A palpable thrombosed aneurysm with absence of all peripheral pulsations was accompanied by neither trophic disturbances nor marked limitation in movement. Collateral arterial channels provided sufficient circulation. The syphilitic history might have suggested syphilitic endarteritis had not the palpable solid tumor and etiology of severe muscular strain at the knee been so pathognomonic.

DISCUSSION

Mechanism.—Aneurysms of the popliteal artery produce disturbances in peripheral circulation even before the onset of local symptoms in the popliteal space. With the arterial pressure at least partially expended in dilating the aneurysmal sac, a corresponding reduction in pressure occurs in the distal circulation. Accordingly, the peripheral arterial pulsations and temperature readings are reduced. By pre-

venting expansion of the aneurysmal sac with direct pressure, there is improvement in the peripheral circulation.[3] This can be likened to a long rubber balloon with a saccular or fusiform weakened area. In expanding such a balloon, the dilating pressure will be spent in the weakened area at the expense of the proximal and distal portion. Conversely, increased peripheral resistance to the flow of blood due to muscular activity or to vascoconstriction from exposure to cold will be accompanied by greater dilatation of the aneurysmal sac. This is well illustrated by the oscillomograms and peripheral temperature readings in the cases herewith reported.

Frequency.—The published reports in the literature are of little value in estimating the frequency of popliteal aneurysms as the cause of peripheral circulatory disease. Generally a diagnosis of aneurysm is made only when the sac is large and (a) a definitely expansile tumor is palpable;[4] (b) when pressure on the adjacent nerves, veins, or joint gives rise to local pain, swelling, or disability;[5] (c) when thrombosis of the sac forms a palpable solid tumor or simultaneous thrombosis of the popliteal artery results in acute peripheral circulatory deficiency;[6] (d) and when the sac ruptures into the knee joint or the surrounding tissues.[7] By the time these complications occur, surgical intervention is usually necessary. Consequently most reports are surgical.

The classical publications on aneurysms, written more than twenty-five years ago, are still the outstanding contributions on the subject. Matas[8] collected reports on 106 surgical aneurysms, covering all the important regions of the body, 62, or 58 per cent, of which were of the lower extremity. Of these 62 cases, 66.4 per cent were of the popliteal artery. Delbet,[9] in 1897, reported on a series of 358 cases of popliteal aneurysms. Autopsy statistics cannot be used since the extremities are rarely included in the dissections. The available statistics are, therefore, of little value in estimating the relative frequency of smaller unoperated as well as the surgically demonstrated popliteal aneurysms as the cause of peripheral circulatory disease. There is no doubt, however, that peripheral aneurysms occur most frequently in the popliteal artery.

Early diagnosis of popliteal aneurysm on local physical findings only is usually difficult. The artery lies deep in the popliteal space and is covered by dense tissue and by the tense popliteal fascia. As a rule, slight flexion and relaxation of the muscles of the knee facilitate palpation of normal arterial pulsation, although even in this position deep digital pressure is necessary.[10] With a patent aneurysmal sac the pulsation is more prominent, but the expansile character or size of the dilatation cannot always be detected because of the tense fascial covering. Furthermore, the bruit or murmur so frequently described as pathognomonic was not present in any of the cases herein reported.

INTERPRETATION OF OSCILLOMOGRAPHS

When the diagnosis is uncertain, oscillomographs may be of help in confirming the presence of an aneurysm. Normal oscillometer readings with distal reduction (Chart I) are: thigh, 4 to 16; upper leg, 3 to 12; and ankle, 1 to 10.[11] At the site of local expansile dilatation of the artery there should be an increased oscillometric index. In reviewing the oscillomographs of more than 200 patients suffering with peripheral circulatory disease, 26 had readings at the knee above the normal 12 units of oscillations. Of these, 9 were on the right side; 6 were on the left side; and 5 were bilateral. This might be accepted to confirm Matas' observation that there is frequent bilateral occurrence of aneurysms of the popliteal artery. Still, I do not believe that an increased reading alone justifies diagnosis of aneurysm. The systemic blood pressures and the vasomotor tone and elasticity of the entire arterial segment must be considered. Friedlander,[12] after studying more than 500 oscillomographs, concludes that the height of the curve is not as important as the form of the graph.

The oscillometric curves herewith illustrated show three distinctive features at the site of the aneurysm: (1) increased height of the curve above the normal limits; (2) absence of normal distal reduction in the height of the curves from the thigh to the ankle; (3) fluctuation in the height of the curve as a result of peripheral vasoconstriction or vasodilatation. The graphs show that oscillometer readings as high as 20 were obtained where ordinarily 3 to 12 is considered normal. Instead of normal distal reduction, Case 1 shows readings at the knee which are 50 per cent greater than at the level of the upper thigh. Furthermore, as shown in Charts II to VI inclusive, distal vasoconstriction (low temperature readings of foot) is accompanied by greatly increased oscillations at the knee. Following release of vasoconstriction (increased peripheral temperatures) the oscillometer readings at the knee were reduced. These observations seem to be sufficiently distinctive to be of help in confirming the diagnosis of peripheral aneurysm. A survey of the literature has been of little assistance in interpreting these observations. For the most part the published reports on oscillomographs deal with interpretations of findings in organic occlusive arterial disease.[13]

ETIOLOGY

Popliteal aneurysms are rarely produced by direct trauma to the artery. Matas[8] observed that when a history of onset is given violent muscle strain or effort which increases arterial tension precedes the initial symptoms. Similarly, Delbet[9] noted that forceful flexion of the leg obstructs the popliteal artery and sudden violent contraction of the muscles raises the blood pressure in the collapsed artery. Rupture of the two inner coats of the vessel results. If the rupture is small, the

aneurysm is slow in forming. A history of violent muscular strain while the knees were flexed is given in Cases 2 and 4 of the present series. That almost all these aneurysms occur in men might be due to the violence of muscular effort.

Syphilis is known to be an etiologic factor in aneurysms, especially those of the aorta. Since the disease attacks the media of the artery, a weakening of the arterial wall may preexist. All the cases in the present series had negative Wassermann tests, although in one case there was a history of syphilis. Delbet's thorough report questions whether popliteal aneurysms are proportionately more frequent in syphilitics, although he noted a greater frequency of aneurysms in Japan where syphilis is more prevalent. He also found that syphilis occurs equally in the army and navy, while these aneurysms are more frequent in soldiers than in sailors. However, syphilis has not been established as an important etiologic factor in the occurrence of popliteal aneurysms.

Occupation may contribute not only to the formation but also to the enlargement of popliteal aneurysm. In Matas' series as well as in Delbet's series of surgical popliteal aneurysms, mostly the laboring class was affected, while, on the contrary, in the series herewith presented none of the patients were of the laboring class. It was noted in the latter case histories and charts that strenuous exercise and exposure to cold produced a marked increase in the oscillations within the patent aneurysmal sac. Naturally the laboring class is subjected to great muscular effort and exposure to cold which may contribute to the rapid development of surgical aneurysms. It is possible that enlargement of the sac may be delayed by avoiding severe muscular exercise or exposure to cold.

ARTERIOGRAPHY

Arteriograms have recently been recommended as an aid in diagnosing and locating popliteal aneurysms. Although Berberich and Hirsch (1923)[14] were the first to use arteriography on living humans, Demel, Sgalitzer, and Kollert (1931),[15] of Vienna, were the first to report thoroughly on the procedure in peripheral circulatory disease. Their experience in 40 cases of arteriosclerotic disease did not include aneurysms. Fontaine and Maitre,[16] Allen and Camp,[17] and others[18] have made similar investigations. Leriche and Arnulf[19] and Barker[20] have reported on the value of arteriography in popliteal aneurysms. A surgical incision of the thigh for isolation of the femoral artery is necessary to inject the roentgen contrast solution.[21] The objections to an intraarterial injection[22] make one hesitant in using this procedure, although in selected cases, especially when multiple aneurysms[23] are suspected, arteriography is the only means of visualizing the exact pathology.

TABLE I

ANEURYSM OF THE POPLITEAL ARTERY; SUMMARY OF CASES

CASE	AGE	SEX	OCCUPATION	EXTREMITY	CAUSE	DURATION PERIPHERAL CIRCULATORY DISTURBANCE	LOCAL FINDINGS POPLITEAL SPACE	PERIPHERAL ARTERIAL PULSATION			GANGRENE	SYPHILIS	
								DP	PT	POP		HISTORY	WASS.
1	56	M	Engineer	Left	Forced flexion; violent muscle action	5 yr.	Large, pulsating tumor	0	0	+++	None	No	Neg.
2	52	M	Policeman	Bilateral	Unknown	10 yr.	Pulsating swelling	++	++	+++	None	No	Neg.
3	61	M	Clerk	Left	Unknown	6 yr.	Pulsating swelling	0	0	++++	Toes and foot	No	Neg.
4	80	M	Merchant	Left	Unknown	1 yr. or more	Firm, nonpulsating tumor	0	0	0	Infection side of first toe	No	Neg.
5	46	M	Contractor	Right	Forced flexion; violent muscle action	15 mo.	Firm, nonpulsating tumor	0	0	0	None	Yes	Neg.

PROGNOSIS

Spontaneous cure by thrombosis of the aneurysmal sac has been observed, but there is the danger of complete occlusion of the popliteal artery, the most serious result of which is gangrene of the toes or foot. However, in 3 of the 5 cases reported, thrombosis of the sac and the popliteal artery produced neither trophic disturbances nor severe disability. The adequacy of collateral circulation depends to a large extent upon the rapidity of the occlusion. In the presence of poor circulation, infection is a most serious complication and led to gangrene in 2 cases. Recent advance in the treatment of peripheral circulatory diseases has improved the prognosis in popliteal artery obstruction. During the past two years I have observed 7 additional extremities with popliteal artery occlusion. In 5 cases, adequate treatment with positive and negative pressure[24] resulted in complete clinical recovery. The 2 cases which were not treated by this method developed extensive gangrene.

SUMMARY AND CONCLUSIONS

Five cases of aneurysm of the popliteal artery in which the primary symptoms were those of peripheral circulatory disease are herewith reported.

Early diagnosis of popliteal aneurysm on local findings only is usually difficult. In the absence of local symptoms in the popliteal space, the presence of an aneurysm may be overlooked. Examination for all peripheral circulatory diseases should include temperature readings, oscillomographs, and differential test for organic and spastic disease.

Oscillomographs as herewith illustrated seem to be sufficiently distinctive to be used in confirming diagnosis of aneurysm. The three features of the curves at the site of the aneurysm are: (1) increased height above the normal limit; (2) absence of normal distal reduction in the height of the curves from the thigh to the ankle; (3) fluctuation in the height of the curve as a result of peripheral vasoconstriction or vasodilatation.

Strenuous muscular exercise or vasoconstriction in the foot and leg as a result of exposure to cold were found to be associated with greatly increased oscillations in the aneurysmal sac. This may explain the reported greater frequency of large surgical aneurysms in men who do heavy laboring work. All five cases herewith reported were men whose occupation did not require heavy work, although in two cases violent muscular effort was accidently incurred. The other three patients had no knowledge of the time of onset of the aneurysms or of the peripheral circulatory disease. Indirect trauma, the result of forced flexion of the knee and violent muscular strain, appears to be

the most important cause of popliteal aneurysm. This was noted by Delbet more than forty years ago.

Spontaneous thrombosis of the aneurysm and popliteal artery may cause gangrene of the extremity. In 3 of the 5 cases that I have reported, arterial obstruction occurred but resulted in gangrene in only 1 case. In this case gangrene developed during prolonged convalescence following amputation of the other extremity.

REFERENCES

1. Scott, W. J. M.: An Improved Electrothermal Instrument for Measuring Surface Temperature, J. A. M. A. **94**: 1987, 1930.
2. Morton, J. J., and Scott, W. J. M.: Methods of Estimating the Degree of Sympathetic Vasoconstriction in Peripheral Circulatory Diseases, New England J. Med. **204**: 955-962, 1931.
   Scott, W. J. Merle, and Morton, John J.: The Differentiation of Peripheral Arterial Spasm and Occlusion in Ambulatory Patients, J. A. M. A. **97**: 1212-1215, 1931.
   White, J. C.: Diagnostic Blocking of Sympathetic Nerves to Extremities With Procaine, J. A. M. A. **94**: 1382-1388, 1930.
   White, J. C.: The Autonomic Nervous System, New York, 1935, The Macmillan Company.
   Brown, G. E.: The Treatment of Peripheral Vascular Disturbances of the Extremities, J. A. M. A. **87**: 379-383, 1926.
   Landis, E. M., and Gibbon, J. H., Jr.: A Simple Method of Producing Vasodilatation in the Lower Extremities, Arch. Int. Med. **52**: 785-808, 1933.
   Coller, F. A., and Maddock, W. G.: The Differentiation of Spastic From Organic Peripheral Vascular Occlusion by the Skin-Temperature Response to High Environmental Temperature, Ann. Surg. **96**: 733-743, 1932.
3. Pachon, V., and Fabre, R.: Clinical Investigation of Cardiovascular Function, London, 1934, Kegan Paul, Trench, Trubner and Co., Ltd.
4. Reid, Mont R., and Andrus, Wm. De W.: Aneurysms, Nelson's System of Surgery, New York, 1927, Thomas Nelson and Sons, Vol. I.
   Brooks, Barney: Diseases of the Blood Vessels, Graham's Surgical Diagnosis, Philadelphia, 1930, W. B. Saunders Company, Vol. I.
5. McKenna, H.: Aneurysm of the Popliteal Artery, S. Clin. North America **2**: 863-867, 1922.
   Bolton, Percival R.: Special Aneurysms, Dennis' System of Surgery, Philadelphia, 1895, Lea Brothers and Co., Vol. II.
6. Leriche, R., and Jung, A.: Nine Aneurysms of the Femoral and Popliteal Arteries With Gangrene of the Foot, Lyon chir. **31**: 182-187, 1934.
   Wells, A. H., Coburn, C. E., and Walker, M. A.: Popliteal Aneurysm, J. A. M. A. **106**: 1264-1266, 1936.
7. Peycelon, R., and Frich, P.: Rupture of Aneurysm of Tibioperoneal Trunk Artery in the Popliteal Fossa, Lyon chir. **32**: 377-379, 1935.
   Steel, W. Ashley: Rupture of Popliteal Artery and Vein, Brit. J. Surg. **1**: 1165-1167, 1935.
   Wakeley, C. P. G., and Reid, W. O.: Subcutaneous Rupture of Popliteal Aneurysm, Lancet **2**: 829-832, 1932.
   Hildman, K. F.: Traumatic Aneurysm of Popliteal Space Due to Tibial Exostosis, Zentralbl. f. Chir. **61**: 2311-2313, 1934.
8. Matas, Rudolph: Surgery of the Vascular System, Keen's Surgery, Philadelphia, 1912, W. B. Saunders Company, Vol. V, p. 344.
9. Delbet, Pierre: Surgical Diseases of the Arteries, Traité de chir. **4**: 141-348, 1897.
10. Buerger, Leo: The Circulatory Disturbances of the Extremities, Philadelphia, 1924, W. B. Saunders Company.
11. Samuels, Saul S.: Value of Oscillometry in the Study of Circulatory Disturbances of the Extremities, J. A. M. A. **88**: 1780-1782, 1927.
    Idem: The Diagnosis and Treatment of Diseases of the Peripheral Arteries, New York, 1936, Oxford University Press.
12. Friedlander, A.: Studies in Oscillometry, Am. Heart J. **9**: 212-218, 1933.
    Idem: Recognition of Types of Arteriosclerosis by Oscillometry, J. A. M. A. **104**: 297-301, 1935.

13. Simpson, S. L.: Oscillometry in Peripheral Vascular Disease, Proc. Staff Meet., Mayo Clin. **5**: 270-272, 1930.
Lian, C.: Study of Oscillometry and Oscillographs, Presse méd. **41**: 160-170, 1933.
De Takats, Geza, and MacKenzie, W. D.: The Diagnosis and Treatment of Circulatory Disturbances of the Extremities, Surg., Gynec. & Obst. **58**: 655-667, 1934.
Vaguez, H., Monguin, M., and Gley, P.: Plateau Form of Oscillometer Curves, Presse méd. **42**: 721-744, 1934.
Friedlander, A.: Reference 12.
14. Berberich, J., and Hirsch, S.: Roentgenography of Blood Vessels, Klin. Wchnschr. **2**: 2226-2228, 1923.
15. Demel, R., Sgalitzer, M., and Kollert, V.: Arteriography, Beitr. z. klin. Chir. **152**: 609-617, 1931.
16. Fontaine, R., and Maitre, R.: Arteriography in Arteritis of the Extremities, J. de chir. **43**: 801-823, 1934.
17. Allen, E. V., and Camp, J. D.: Value of Arteriography, Radiology **22**: 678-683, 1934.
Idem: Radiography of the Arteries of the Extremities, Proc. Staff Meet., Mayo Clin. **7**: 657-662, 1932.
18. Veal, J. Ross, and McFetridge, E. M.: Vascular Changes in Intermittent Claudication, Am. J. M. Sc. **192**: 113-121, 1936.
Idem: Arteriography in Gangrene of the Extremities by the Use of Thorium Dioxide, Ann. Surg. **101**: 766-775, 1935.
Dos Santos, R., Lamas, A. C., and Caldas, J. P.: Arteriography of the Extremities, Bull. et mém. Soc. nat. de chir. **58**: 635-663, 1932.
Singleton, A. O.: Use of Intra-Arterial Injection of Sodium Iodide in Determining Condition of Circulation in the Extremities, Arch. Surg. **16**: 1232-1241, 1928.
Leibovice, R.: Arteriography in Gangrene of the Lower Extremities, J. de chir. **34**: 293-310, 1929.
Saito, M., Kamikawa, K., and Yanagizawa, H.: Blood Vessel Visualization in Vivo, Am. J. Surg. **10**: 225-240, 1930.
Carnett, J. B., and Greenbaum, S. S.: Blood Vessel Visualization, J. A. M. A. **89**: 2039-2041, 1927.
Brooks, Barney: Intra-Arterial Injection of Sodium Iodide, J. A. M. A. **82**: 1016-1019, 1924.
19. Leriche, R., and Arnulf, G.: Multiple Aneurysms, Lyon chir. **31**: 227-229, 1934.
20. Barker, N. W.: Arteriography, M. Clin. North America **18**: 613-622, 1934.
21. Pearse, H. E., Jr., and Warren, S. L.: The Roentgenographic Visualization of the Arteries of the Extremities in Peripheral Vascular Disease, Ann. Surg. **94**: 1094-1102, 1931.
Milch, H., and Kling, D. H.: Visualization of Ruptured Popliteal Aneurysm, M. J. & Rec. **137**: 425-427, 1933.
Barker, N. W.: Reference 20.
22. White, J. C.: The Autonomic Nervous System, New York, 1935, The Macmillan Company.
Demel, R., Sgalitzer, M., and Kollert, V.: Reference 15.
Milch, H., and Kling, D. H.: Reference 21.
23. Leriche, R., and Arnulf, G.: Reference 19.
Leriche, R., and Jung, A.: Reference 6.
24. Hermann, L.: Passive Vascular Exercises, Philadelphia, 1936, J. B. Lippincott Company.
Landis, E. M., and Hitzrot, L. H.: Clinical Value of Alternate Suction and Pressure in the Treatment of Advanced Peripheral Vascular Disease, Am. J. M. Sc. **189**: 305-324, 1935.
Theis, F. V., and Freeland, M. R.: Peripheral Circulatory Diseases: Effect of Alternating Positive and Negative Pressure Treatments on Venous Blood and the Skin Temperatures. Preliminary Report, J. A. M. A. **107**: 1097-1104, 1936.

THE DISTRIBUTION OF ANHIDROSIS FOLLOWING INTERRUPTION OF VARIOUS SYMPATHETIC PATHWAYS IN MAN*

GRACE M. ROTH, PH.D., ROCHESTER, MINN.

(From the Mayo Foundation)

THE sweat glands are innervated by the thoracolumbar or sympathetic division of the autonomic nervous system. The spinal centers for innervation of the sweat glands of the head, neck, upper extremity, and upper portion of the thorax are between the eighth cervical and the sixth thoracic segments. The preganglionic portions of these upper thoracic segments are distributed mainly to the upper thoracic and cervical ganglions. From these ganglions the secretory nerve fibers join the peripheral nerves by way of the gray rami communicantes and arrive at the sweat glands by way of the cutaneous nerves. The spinal centers for the lower part of the trunk and lower extremities are between the sixth thoracic and upper lumbar segments. The preganglionic fibers pass to the ganglions of the sympathetic trunks. From these ganglions the secretory nerve fibers join, by way of the gray rami communicantes, the spinal nerves and are distributed peripherally through the cutaneous branches of these nerves. The sympathetic secretory nerve fibers are intimately associated with the sympathetic fibers to the peripheral arterial system, the sebaceous glands, and the pilomotor muscles.

A method for determining the distribution of the secretory nerve fibers to the sweat glands of man was made possible by the advent of surgical procedures on the sympathetic nervous system for peripheral vascular disease.[1, 2] As other clinical conditions, such as essential hypertension,[3, 4, 5, 7, 12] became amenable to treatment to surgical interruption of the vasomotor pathways, study of the distribution of the secretory nerves to the sweat glands was enlarged in scope. In this work, the surgical operations were performed by Adson and Craig, using the procedures especially developed by them. The extent of the surgical procedures will be described in detail in the section on material.

In man, sweating produced by heating the body indicates the presence of sympathetic secretory fibers.[8] The response occurs as a reflex, mediated through the central nervous system and the sympathetic

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nerve supply to the sweat glands. Whenever the vasomotor pathways to a given cutaneous area are interrupted, sweating in that area, induced reflexly by heat, ceases permanently.[8] I wish to present in this paper the distribution of anhidrosis following interruption of various sympathetic pathways.

METHODS

In the method[11] used to determine the presence or absence of sweating, heat and calorimetry were employed. Determinations were based on the chemical fact that cobaltous chloride, in a saturated alcoholic solution, is deep blue but turns to bright pink on the addition of water. The patient is stripped; a small amount of this saturated solution is applied over the parts in which the presence or absence of sweating is to be determined. A small brush is used and the solution is either dotted on the skin or applied in stripes. The skin dries readily if the solution is put on in small quantities. To produce sweating, an aluminum heat cabinet large enough to cover the entire body and containing a series of incandescent globes is placed over the patient. A temperature of 130 degrees F. to 140 degrees F. is maintained until sweating has been induced. If sweating is delayed, a hot drink will hasten its appearance. The heat cabinet is then removed and the portions of skin to which the solution has been applied are observed immediately. Where sweating has occurred, the dots or stripes of solution are bright pink. In places where varying degrees of sweating can be observed, the transition can be noted with considerable accuracy by the change in color of the stripes. On humid days, sufficient moisture may be present in the air to effect a change in color of the solution, but it is never the deep pink observed in the presence of sweating. Furthermore, the heat cabinet eliminates the factor of atmospheric moisture.

In a few cases, in addition to use of the above mentioned method, pilocarpine hydrochloride was used; $\frac{1}{10}$ to $\frac{1}{5}$ grain (0.006 to 0.013 gm.) was given intramuscularly and without the use of heat. These tests were made at various intervals following the surgical procedures.

MATERIAL

The tests were carried out on seventy-seven subjects. They were placed in two major groups, dependent on whether surgical procedures had or had not been performed.

Group I was composed of subjects who were not operated upon; this group included ten normal subjects and ten patients who had postural or orthostatic hypotension.

Group II was composed of fifty-seven patients who had undergone surgical procedures for interruption of various sympathetic pathways.

Twelve of these fifty-seven patients had peripheral vascular disease. Of these twelve patients, six had been subjected to lumbar sympathectomy; five to cervicothoracic sympathectomy; and one to both cervicothoracic and lumbar sympathectomy. The other surgical procedures were performed on forty-five patients who had essential hypertension. The types of sympathetic section were as follows: (1) bilateral removal of the second, third, and fourth lumbar ganglions and the intervening sympathetic trunk (generally referred to as bilateral lumbar sympathectomy); (2) bilateral removal of the inferior cervical and first and second thoracic ganglions and intervening sympathetic trunk (generally referred to as bilateral cervicothoracic sympathectomy); (3) bilateral resection of the intercostal nerves from

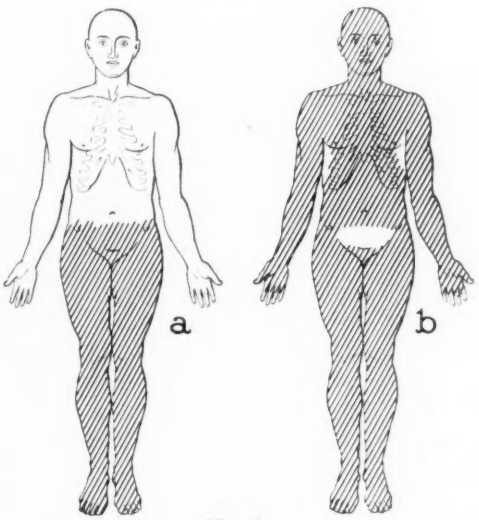

Fig. 1.

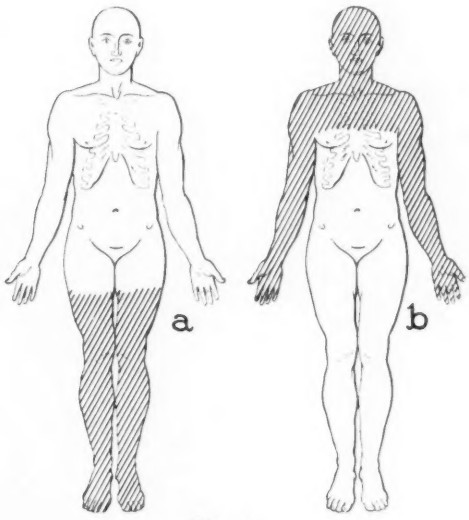

Fig. 2.

Fig. 1.—Anhidrosis associated with postural hypotension. In this and in succeeding illustrations, the shaded portions indicate areas of anhidrosis: *a*, usual distribution; *b*, distribution in a severe case.

Fig. 2.—Effects of different operations performed for peripheral vascular disease: *a*, bilateral lumbar sympathectomy; *b*, bilateral cervicothoracic sympathectomy.

the seventh to the eleventh, inclusive; (4) posterior infradiaphragmatic bilateral splanchnic resection with bilateral removal of the first lumbar ganglions; (5) extensive bilateral splanchnic resection, partial resection of the celiac ganglion, partial bilateral resection of the suprarenal glands, and bilateral removal of the first and second lumbar ganglions; (6) bilateral ventral rhizotomy (each of the following inclusive) from the eleventh thoracic to the second lumbar, from the tenth thoracic to the second lumbar, from the ninth thoracic to the second lumbar, from the eighth thoracic to the second lumbar, from the seventh thoracic to the second lumbar, from the sixth thoracic to the twelfth thoracic, from the sixth thoracic to the second lumbar, and from the fifth thoracic to the second lumbar.

RESULTS

With this method, profuse sweating has been observed over the entire body of normal individuals. In all the illustrations, the shaded portions correspond with the areas of anhidrosis. In the group of patients with postural or orthostatic hypotension, the absence of sweating was found for the most part in an area below the umbilicus, although variations occurred (Fig. 1). The observations following bilateral lumbar sympathectomy and bilateral cervicothoracic sympathectomy have been reported previously by Brown and Adson[6] (Fig. 2). Figures 3 and 4 demonstrate the areas of anhidrosis following various operations performed on patients who had essential hypertension.

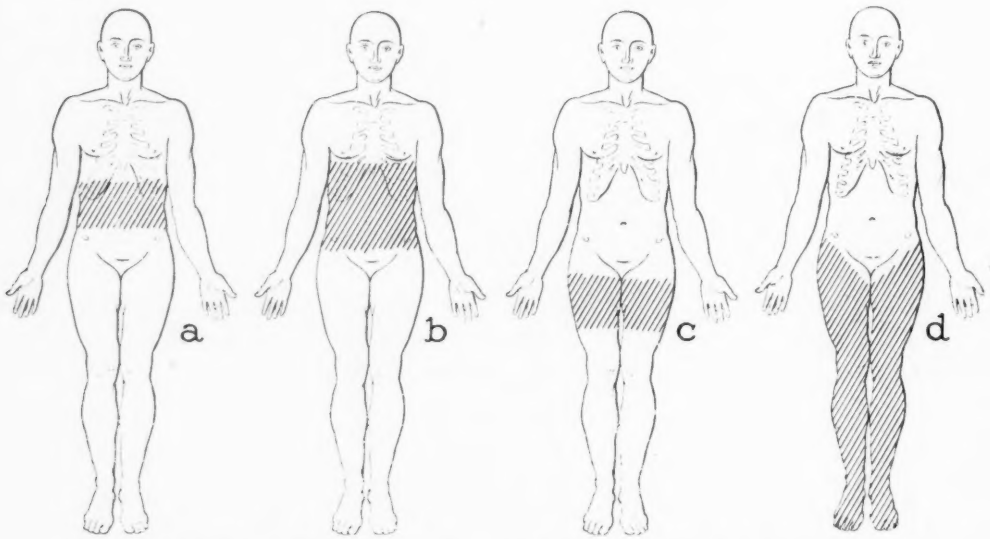

Fig. 3.—Effects of different operations performed for essential hypertension; *a*, bilateral resection of intercostal nerves from the seventh to the eleventh inclusive; *b*, ventral rhizotomy from the sixth thoracic to the twelfth thoracic, inclusive; *c*, posterior bilateral infradiaphragmatic splanchnic resection with bilateral removal of the first lumbar ganglions; *d*, extensive bilateral splanchnic resection, partial resection of the celiac ganglion, partial bilateral resection of suprarenal glands and bilateral removal of the first and second lumbar ganglions.

Figure 3 *d* requires further discussion. It represents twelve patients following extensive bilateral resection of the splanchnic nerves, partial resection of the celiac ganglion, and bilateral partial removal of the suprarenal glands, with bilateral removal of the first and second lumbar ganglions. The patients had, as a consequence, complete anhidrosis from the level of the inguinal sulcus, extending downward and including the lower extremities. In addition, at a subsequent time, to four of these patients ⅙ grain (0.01 gm.) of pilocarpine hydrochloride was administered intramuscularly and the areas of anhidrosis noted. These tests were carried out at varying periods following operation. On two patients the tests were made fifteen days after the

final surgical procedure. Under the influence of pilocarpine the first of these patients had slight sweating over the inner aspects of both legs, down to the medial malleoli; with heat, complete anhidrosis was demonstrated in this area. The second patient, except for the feet, did not sweat in the area which had been anhidrotic under the influ-

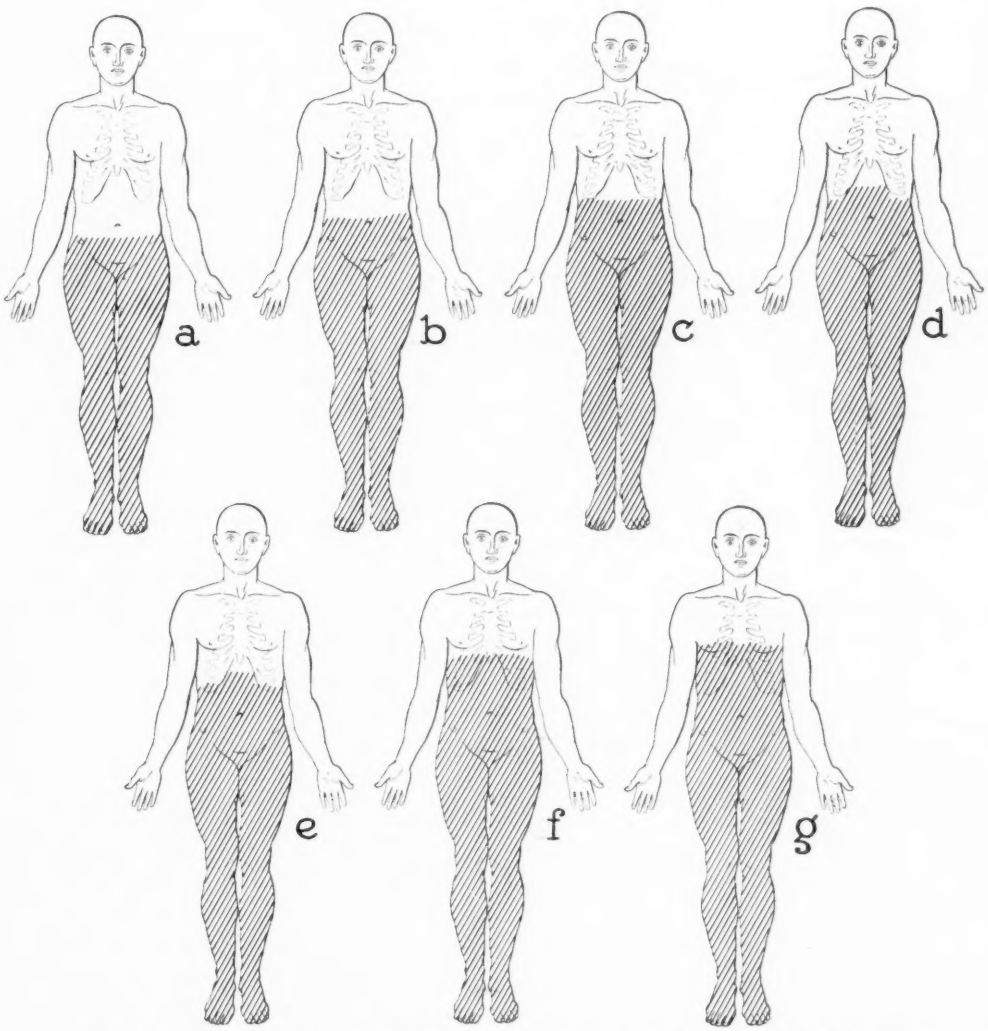

Fig. 4.—Effects of bilateral ventral rhizotomy on patients with essential hypertension: *a*, eleventh thoracic to second lumbar inclusive; *b*, tenth thoracic to second lumbar inclusive; *c*, ninth thoracic to second lumbar inclusive; *d*, eighth thoracic to second lumbar inclusive; *e*, seventh thoracic to second lumbar inclusive; *f*, sixth thoracic to second lumbar inclusive; *g*, fifth thoracic to second lumbar inclusive.

ence of heat. The test was carried out twenty-seven days after operation on the third patient. In this instance the area of anhidrosis, as demonstrated by heat and by pilocarpine, was the same. Under the influence of pilocarpine, the fourth patient, who was tested with the drug six months after the operation, had only the slightest persistent

sweating over the lateral dorsal aspect of the feet. Otherwise the area of anhidrosis was the same as that demonstrated by heat.

On a fifth patient, on whom cervicothoracic sympathectomy and lumbar sympathectomy had been performed three years previously, complete anhidrosis was demonstrated, by use of heat, over the face, on the chest bilaterally to a level 10 cm. below the clavicle, over the upper extremities and over the lower extremities from the knees downward. Following administration of pilocarpine, however, anhidrosis was present over the entire body, with the exception of the face and axilla, where excessive sweating was noted along with slight sweating on the abdomen.

COMMENT

In his early work on cats, Langley[9] demonstrated a parallel course for the nerve fibers which control vasomotor reactions and sweating. If the vasomotor fibers are completely removed, sweating cannot be demonstrated. In a later work[10] Langley stated further that, in cats, the area of skin supplied by the gray rami of each ganglion corresponds in the main with the area of skin supplied by the homologous posterior root fibers. This study on man tends to confirm the work of Langley as to the distribution of the secretory nerve fibers.

Although the diagrams show definite linear levels of anhidrosis, some variations in the line of demarcation of complete anhidrosis were observed. Apparently some overlapping occurred in the segmental distribution of the secretory nerve fibers. Of areas of anhidrosis which included the upper or lower extremities, the driest portions were on the hands and feet respectively. In some instances definite scaling of the feet occurred.

It is generally conceded that pilocarpine has a direct action on the sweat glands. For the most part, tests carried out with pilocarpine within a month following sympathectomy show that sweating can be induced. In these patients, the amount of sweating induced with pilocarpine hydrochloride was diminished before the end of one month. It is of interest to note that under the influence of pilocarpine, the patient who had undergone both cervicothoracic and lumbar sympathectomy three years previous to administration of the drug, excessive sweating occurred over the entire face and neck. This was in contrast to a lack of sweating in this area under the influence of heat. An explanation is found in the recent work of Wilson,[13] who demonstrated a double innervation, both sympathetic and parasympathetic, of the sweat glands of the human face.

The distribution of anhidrosis of patients who have postural or orthostatic hypotension simulates, in many instances, the distribution of anhidrosis following extensive interruption of the sympathetic vasomotor pathways.

SUMMARY

Following the interruption of various sympathetic pathways, anhidrosis occurred in cutaneous areas that corresponded closely to the segmental level at which the sympathetic nerves were distributed in the spinal nerves. The area of skin supplied by the gray rami of each ganglion corresponds in the main with the area of skin supplied by the homologous posterior root fibers.

REFERENCES

1. Adson, A. W., and Brown, G. E.: Treatment of Raynaud's Disease by Lumbar Ramisection and Ganglionectomy and Perivascular Sympathetic Neurectomy of the Common Iliacs, J. A. M. A. **84**: 1908-1910, 1925.
2. Adson, A. W., and Brown, G. E.: The Treatment of Raynaud's Disease by Resection of the Upper Thoracic and Lumbar Sympathetic Ganglia and Trunks, Surg., Gynec. & Obst. **48**: 577-603, 1929.
3. Adson, A. W., and Brown, G. E.: Malignant Hypertension: Report of Case Treated by Bilateral Section of Anterior Spinal Nerve Roots From the Sixth Thoracic to the Second Lumbar, Inclusive, J. A. M. A. **102**: 1115-1118, 1934.
4. Adson, A. W., Craig, W. McK., and Brown, G. E.: Essential Hyperhidrosis Cured by Sympathetic Ganglionectomy and Trunk Resection, Tr. West. S. A. 383-400, 1934.
5. Adson, A. W., Craig, W. McK., and Brown, G. E.: Surgery in Its Relation to Hypertension, Surg., Gynec. & Obst. **62**: 314-331, 1936.
6. Brown, G. E., and Adson, A. W.: Physiologic Effects of Thoracic and of Lumbar Sympathetic Ganglionectomy or Section of the Trunk, Arch. Neurol. and Psychiat. **22**: 322-357, 1929.
7. Brown, G. E., and Craig, W. McK.: The Physiological Effects of Unilateral and Bilateral Resection of the Major and Minor Splanchnic Nerves in Man, Tr. A. Am. Physicians **48**: 213, 1933.
8. Kuntz, Albert: The Autonomic Nervous System, ed. 2, Philadelphia, 1934, Lea & Febiger, pp. 272-280.
9. Langley, J. N.: On the Course and Connections of the Secretory Fibres Supplying the Sweat Glands of the Feet of the Cat, J. Physiol. **12**: 347-374, 1891.
10. Langley, J. N.: Further Observations on the Secretory and Vasomotor Fibres of the Foot of the Cat, With Notes on Other Sympathetic Nerve Fibres, J. Physiol. **17**: 296-314, 1894-1895.
11. Roth, Grace M.: A Clinical Test for Sweating, Proc. Staff Meet. Mayo Clin. **10**: 383, 384, 1935.
12. Rowntree, L. G., and Adson, A. W.: Bilateral Lumbar Sympathetic Neurectomy in the Treatment of Malignant Hypertension: Report of Case, J. A. M. A. **85**: 959-961, 1925.
13. Wilson, W. C.: Observations Relating to the Innervation of the Sweat Glands of the Face, Clin. Sc. **2**: 273-286, 1936.

THE OPERATIVE MANAGEMENT OF FIBROUS CONSTRICTING PERICARDITIS*

PROFESSOR V. SCHMIEDEN AND DR. H. H. WESTERMANN,
FRANKFURT AM MAIN, GERMANY

(From the Surgical University Clinic)

THE condition of dense fibrosing and calcified pericarditis is by no means as infrequent as is commonly supposed. Its assumed rareness is due to the teaching of clinicians who observe the condition relatively rarely during their lifetime. On the other hand, pathologists very frequently find adhesive pericarditis at autopsy as a secondary finding. These fibrous adhesions are also partly interspersed with considerable amounts of calcium deposit, although they may not have produced any disturbing influences on the heart during life. Hence, it becomes evident that the surgeon sees only the worst cases which are in urgent need of relief.

Two circumstances are responsible for the appearance of grave functional disturbances of the heart: First, the contiguous infiltrative involvement of the mediastinum with a binding of the pericardium to the posterior wall of the sternum (accretio cordis); second, the development of concentric shrinking of cicatricial tissue with a constriction of the heart and a throttling of the entrance and exit of the larger vessels (concretio pericardii retrahens).

The affections of the pericardium, particularly pericardial effusion, were known to the older physicians, such as Galen, Forestus, and Riolan. However, for a more accurate knowledge of the symptomatology of this pathologic change in the pericardium, we are indebted in recent years to two German teachers who have more accurately studied this condition.

Pick was the first to recognize the symptoms which suggested the diagnosis. Since the whole picture of the disease is deceptively similar to liver cirrhosis, as considerable ascites is also present in this disease, he named it *Pseudolebercirrhose* or pseudohepatic cirrhosis, although he was not able to discern the underlying causes.

On the other hand, Volhard first gave a comprehensive description of the clinical picture which is due to an obstruction of the venous circulation, and which he designated by the term *Einsflusstauung* or inflow-stasis. This stasis is produced by a hindrance to the inflowing blood of the vena cava at the right auricle, causing venous pulsation in

*Translated by Michael DeBakey, M.D., Tulane University School of Medicine, New Orleans, La.

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the neck as well as transudation of fluid in the body cavities (thoracic and abdominal cavities). The liver, being a blood reservoir, in series with the heart also swells and enlarges like a congested organ. Thus, when the disease develops in this manner, it manifests itself by a synchronous retraction and diastolic bulging of the chest wall with each movement of the heart associated with a strikingly small pulse. Very often the calcium-hard cicatrix constricts the heart so firmly that the apex beat can no longer be felt (*"Stille über dem eingemauerten Herzen"—"Quietness over the encased heart"*). Roentgenography, which shows very characteristic changes, greatly facilitates the diagnosis. When the disease is still in the early stage of exudative effusion, the heart shadow appears as an isosceles triangle with the apex above. In the cases which have progressed to cicatricial contraction, one finds a strikingly small heart shadow in which contraction is scarcely discernible. Very frequently the onion-peel arrangement of calcium deposits is observed and occasionally small residual cavities. Kymographic examinations of the heart in different oblique directions clearly reveal the degree of motility still present in systole and diastole, so that from the photograph it is possible to ascertain with a great degree of certainty which parts of the heart are most involved and need release.

Through Volhard's work we have learned to make the diagnosis earlier and to differentiate the disease from mitral stenosis, in which the symptoms are sometimes similar. He wrote: "A functionally similar, or even the same, condition occurs in concretio pericardii as in the most severe forms of mitral stenosis. In the latter we likewise find an abnormal output of the left heart, the same small pulse of little amplitude, and an intense inflow stasis with the characteristic elevation of venous pressure, liver enlargement, and preponderant ascites. The increase in venous pressure corresponds to a marked overfilling of the right heart with dilatation of the conus pulmonalis and especially the right auricle, which in contrast to the pericardial constriction generally is followed by a permanent irregular pulse. Both the dilatation of the right auricle and the conus pulmonalis have a characteristic roentgenographic appearance. The congested cervical veins not only show a diastolic collapse, but also a systolic swelling, because in this stage of mitral stenosis a functional or organic tricuspid insufficiency regularly exists. Indeed, not infrequently we even see a systolic retraction and a swinging movement of the precordial region where the ventricle lies adjacent to the chest wall, which reminds one of the chest wall retraction of mediastinopericarditis. But instead of quietness over the encased heart, we feel here the mighty heaving action of the right ventricle over the area of cardiac dullness and under the left costal arch and hear the characteristic mitral rhythm and the diastolic murmur over the apex as it strikes the chest wall. In the presence of these a mistake is hardly possible, but it

is theoretically of greatest interest that in different ways this combination of an abnormally small cardiac output with stasis on the venous side of the heart produces the same clinical picture and the predominance of portal stasis over peripheral stasis.'' Because he was cognizant of these facts, the senior author has never had a mistaken diagnosis in the twenty-two cases he personally operated upon.

The disease begins as a fresh exudative inflammation of the pericardium, which produces marked symptoms, usually subsides in children, and is due either to tuberculosis or metastatic suppuration following rheumatic arthritis.

The early exudative form of the condition has long been treated by aspiration or drainage of the pericardium and has also produced excellent results when the diagnosis is made early.

No one dared operative intervention in the terminal stage, in which the prognosis was grave and life was endangered by cardiac constriction, until 1898, when DeLorme proposed operating for this condition. Apparently his proposal was not put in actual practice—at least there is nothing found in the literature about it.

Brauer inaugurated, in 1902, another type of operation which would relieve the heart of its excessive work (*''Sysiphusarbeit''*) of systolic retraction and chest wall movement. He recommended a mobilization of the bony thorax by removing the ribs adhering to the pericardium. This supposedly gave the heart a soft covering instead of a bony one, thus removing from the heart the tremendous additional labor of the chest wall retraction.

This technique, which has been named *''cardiolysis praecardiaca,''* unfortunately has very limited indications. It can be employed in only those few cases in which the pericardium is attached only to the posterior aspect of the sternum. In the majority of cases this operation is insufficient, because the principal cause of the functional hindrance is not the attachment to the sternum, but is due to the binding constriction of the heart itself.

For this reason, L. Rehn proposed a further step to DeLorme's technique; i.e., partial resection of the pericardium.

The results obtained by this new operative technique of excision of the pericardium have made it the method of choice. The senior author, in collaboration with the medical clinic under Volhard, first in Halle and later in Frankfurt am Main, has operated upon twenty-two cases.

The prognosis of nonoperative cases in the progressive constricting adhesive pericarditis is absolutely hopeless. With increasing cardiac insufficiency and increasing hydrops and hepatic engorgement, death ensues after months of miserable confining illness.

The cicatricial constriction existing over a long period of time produces generalized injury to the organism which is distinctly manifested

in children with this disease by their marked stunting in bodily development, so that they very rarely reach puberty when they are not operated upon.

Remarks of young patients who have undergone operation, such as "I am stronger and now take part in athletics" or "I am feeling fine

Fig. 1.—X-ray pictures of the heart which is surrounded by extensive calcified scarring.

and am very happy about it," should be an indication for operation, even to a hesitating surgeon.

The operative management begins with a very intensive preoperative medical treatment. The burden on the heart must be lightened by relieving the marked hydrops. The administration of a sodium chloride-

free diet and the utilization of diuretics aid in diminishing edema. In order to completely remove the excess fluid, it is often necessary to aspirate the pleural and peritoneal transudates. If following these measures the heart functions better, its activity can be strengthened and its beating regulated by sufficiently large doses of strophanthin.

The difficulties of operative intervention will be greatly diminished if local analgesia is used whenever possible. Numerous investigations have shown that the precordium and heart musculature are completely insensitive, so that one can depend solely upon the technique of a good local analgesia.

For exigency, the positive pressure apparatus should always be available for use during the entire operation, so that in case a large tear of the pleura occurs, the defect can be sutured under forced respiration. In excision of the pericardium the anterior margin of the left pleural fold *(Complentärraum)* is the most likely place to tear. Very often here an extremely delicate pleura borders upon a dense calcified pericardium, so that a complete backward mobilization of the pleura cannot always be done.

Before resection of a portion of the pericardium was done, the question arose whether this would be possible without damage to cardiac function. Numerous physiologic experiments, especially the fact that no disturbance ever appeared following operation, and the magnificent results of operation have shown that no damage whatever occurs to the heart.

As a result of the long-existing fibrosing constriction of the heart musculature, it often unfortunately undergoes an inactivity atrophy, so that its strength and function are considerably impaired.

Because of the anatomic position of the heart, in that the right ventricle occupies the most anterior position, the surgeon is likely first to free this chamber, which has a weaker musculature. If the weak musculature of the right ventricle is suddenly deprived of its callous support by decortication, while the left ventricle remains encased in scar, it can no longer resist this additional burden and dilates or even ruptures. Thus, this technical error may result in acute dilatation of the heart associated with tricuspid insufficiency. A single unfortunate experience of such an overdilatation which led to a fatal termination on the table demonstrated this great danger to Schmieden and he suggested appropriate measures to be used in preventing it. Therefore, the operative technique is based upon the following fundamental principles: (1) liberation of the left ventricle first, in order that it can receive and immediately deliver to the systemic circulation the increased output of the right ventricle following its subsequent decortication and thus avoiding the right-sided venous congestion that would otherwise occur; (2) freeing of the right ventricle, which then usually dilates more effica-

ciously and beats stronger. The final freeing of the right heart should be done in a systematic successive manner. Owing to the thin wall of the auricles, these should not be freed.

Whereas previously there was considerable discussion as to the extent of the decortication, at the present time the important question is a consideration of what parts of the thickened pericardium should be allowed to remain as support to the weakened heart musculature. Because of the above described danger of an acute tricuspid insufficiency and also in order to avoid the development of deficiency of the auriculoventricular valves, thus leading to the immediate occurrence of an inflow venous congestion, the decortication should never be performed beyond the coronary sulcus.

With a cognizance of these fundamental facts, the operative technique of Schmieden was evolved in the following manner: "The type of skin incision may vary considerably and is, in the main, rather unessential. The third to the fifth costal cartilages inclusive, with the adjacent portions of the ribs and a large portion of the sternum, are resected. I have an impression that a large window in the chest is more conducive to a lasting recovery and further favors later mobility of the heart in its new bed. Thus, the *pericardiectomy* begins with the cardiolysis praecardiaca.

"Following this I recommend the attempt to proceed toward the pericardium between the two unopened pleural layers. The adjacent costal and mediastinal pleurae are usually thickened enough so that their tearing can be very well avoided. However, the availability of the positive pressure apparatus is necessary, because if an accidental opening of the pleura should occur it can be sutured immediately without any untoward incident. Transpleural approach may occasionally permit the pericardium to be reached more quickly, but because of the phrenic nerve it is not the most suitable position and may result in postoperative complications. Considerable difficulties may be encountered in effecting hemostasis in this chronically inflamed tissue, and in spite of all efforts it may often be incomplete. Therefore, two or three small drainage tubes are employed in closing the wound, which heals by primary union. After the removal of the tubes there may be slight bleeding or an abundant serous discharge which escapes between the sutures. The adequate removal of this fluid undoubtedly contributes toward healing without recurrence.

"The question of how liberation of the heart should be done after mobilizing the pleura may be answered best by a comparison. It is peeled not like an apple, but like an orange. The secret is to get into the correct line of cleavage, and after pulling off the coarse mantle, to continue excision of the separated strips of pericardial callus until one can see the muscle fibers of the heart everywhere, which become visible

as each successive piece of scar tissue is extirpated. Also in this regard the procedure is similar to the peeling of an orange, because one must afterward clean off scar tissue at different sites.''

In order to immobilize the free-lying border of the anterior pleural fold, for the past few years the senior author has attached it to the left

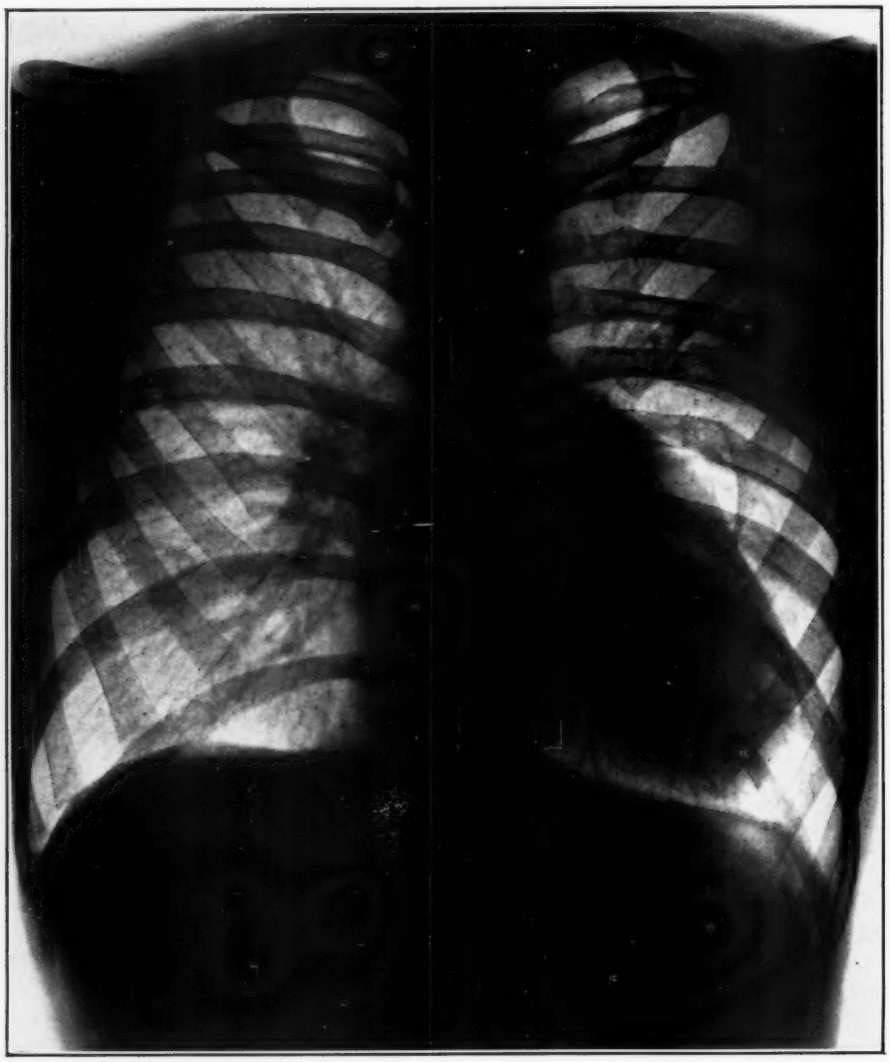

Fig. 2.—X-ray pictures of a case of pericarditis four years after operative liberation. The hernia-like protrusion of the left ventricle is very distinct.

margin of the thoracic window and thus also protected it during operation. This technique he terms *''Exopericardiopexie.''*

After the completed operation, the pectoralis muscle is excised in order not to form an undesirable adhesion to the heart, and the skin flap with the adhering subcutaneous fat is replaced and sutured.

The arrest of hemorrhage is usually not completely effected so that for a short period of time several rubber drains are placed in the wound. This drainage may perhaps account for disturbances which occur in the postoperative course, because the atmospheric air is now in contact with the free-beating heart. On these grounds, avoidance of drainage has been advocated in the Anglo-American literature in order to prevent the atmospheric variations in pressure.

Special attention must be given the apex of the heart which is usually firmly fixed and considerable difficulty is encountered in the attempts to liberate it. If decortication of the apex of the heart, which is bound down to the diaphragm, should not be successful, normal systolic contraction is impossible, because during inspiratory depression of the left dome of the diaphragm the heart is elongated and during systole becomes lancet shaped. In order to remedy this undesirable condition left-sided phrenicotomy is generally recommended, since this results in sufficient relief.

The entire operation can usually be performed through an anterior flap incision described by the senior author. In his twenty-two cases, he was obliged only once to do a second-stage operation in order to free a larger portion of the left ventricle. This second intervention was achieved transpleurally through an intercostal incision. This method of approach should be reserved for cases in which one particularly wants to free only the left ventricle. It has advantages and disadvantages. The results of operative management with a consideration of all details follow:

27.3 per cent (6 cases)	Perfect healing with restoration of full ability to work
27.3 per cent (6 cases)	Very marked improvement and preservation of life after long observation
4.5 per cent (1 case)	Death at operation of acute dilatation of the right ventricle
31.9 per cent (7 cases)	Death during postoperative period
9.0 per cent (2 cases)	Death after transitory improvement

The last two groups of death which unfortunately occurred during the postoperative period or after a transitory improvement may seem discouraging, since this forms 40 per cent of the whole material. The high postoperative mortality is due to the dangers caused by the sudden appearance of insufficiency of the cardiac musculature which has been freed from its constriction and thus deprived of its support. In considering these results of operation, it must be remembered that the great majority of the cases were far advanced and had an extremely bad prognosis.

The best criterion of the operative success and of the state of the heart is the venous pressure. Also, after a successful operation for a

period of time the heart needs the help of strophanthin. As regards the diet, the patient should be restricted in several respects: Fluids are limited and a diet poor in sodium chloride is prescribed. For this reason, the close cooperation of an internist before and after the operation is very necessary.

The death of most of the patients, even after a transitory improvement, was due to their primary disease, which in almost all the cases was tuberculosis of the lungs or the bronchial lymph nodes. While writing this paper, there is a young female patient in preparation for operation. Thus far, the clinical course of her disease and the x-ray pictures indicate a relatively good prognosis. It is very probable that in this case, which is the first to be admitted to the clinic in such good general condition, it will not be necessary to perform extensive excision of the pericardium, but probably the removal of only a small strip of constricting scar will suffice. Greater interest should be aroused in the early symptomatology of dense, binding, fibrosing pericarditis, so that patients are brought to the surgeon while they are still in good general condition and have an efficient cardiac action. Only under these circumstances will it be possible to do away with extensive resection of the pericardium and to be able to do in the future only the simple separation of the armor plate. Under these circumstances we shall be able to save many a life which has been considered as lost.

HIGH FREQUENCY TRANSMISSION OF STIMULATING IMPULSES

HENRY NEWMAN, M.D., FREDERICK FENDER, M.D., AND WILLIAM SAUNDERS, E.E., SAN FRANCISCO, CALIF.

(From the Department of Medicine [Division of Neuropsychiatry] and the Department of Surgery of Stanford University Medical School. Financed by a grant from the Rockefeller Foundation)

THE importance of electrical stimulation of nervous tissue in physiologic research needs no comment. In acute experiments it is not difficult to stimulate directly the exposed nerve in the anesthetized animal, and much of our knowledge of neurophysiology has been obtained in this fashion. Nevertheless, the need for a satisfactory method for obtaining prolonged stimulation in the intact, unanesthetized animal long has been felt.

The permanent implantation of electrodes in the subject, with wire leads carried to the surface of the body, where they might be connected to the source of stimulating current after the recovery of the animal from operation, was pioneered by Hess.[1] This method has a limited sphere of usefulness because of the impossibility of maintaining the point of exit of the wires in a sterile condition over long periods and the restriction of free motion of the subject under stimulation.

In order to eliminate the necessity of connecting the electrodes and the source of stimulating current, the idea was conceived of substituting electromagnetic coupling. Chaffee and Light[2] made use of a periodically charged condenser of large capacity which discharged a very considerable current through a coil thirty-six inches in diameter. This discharge produced an intense electromagnetic field, so that a small coil implanted in the subject received an induced current which was carried by wire leads to the structure to be stimulated. The subject was confined in a twenty-inch cubical cage suspended in the center of the primary coils. It was found necessary to have three primary coils, in three planes mutually perpendicular to each other so that effective coupling could be maintained regardless of the position of the secondary coil. The three coils had to be energized in sequence, and for this purpose an elaborate vacuum tube switching circuit had to be devised to handle the heavy current.

At about the same time, and independently, Fender[3] devised an apparatus in which the primary coils were energized by 60 cycle

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alternating current from lighting mains. Six coils were employed, two in each of the three planes, giving a very uniform field intensity in the central cage in which the subject was placed. The implanted coil was of 6,000 turns of very fine wire and was somewhat smaller

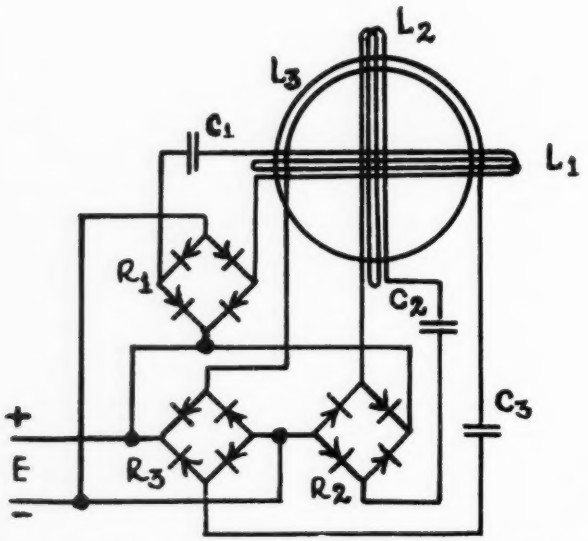

Fig. 1.—Implanted unit. *R*, copper oxide rectifiers; *C*, .00025 mfd mica condensers; L_1 and L_2, coils of 145 turns No. 30 enameled wire wound perpendicularly over L_3, a similar coil of 110 turns; *E*, electrodes. Outside diameter 1½ inches.

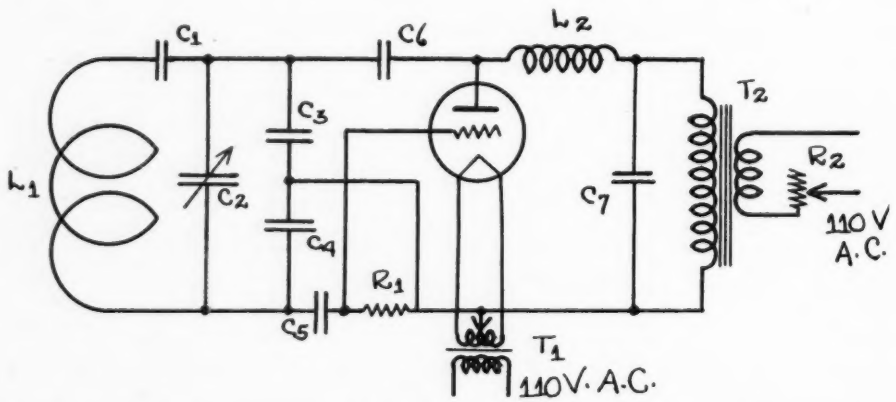

Fig. 2.—High frequency supply circuit. L_1 consists of 6 turns of No. 14 wire around an enclosure 5 feet square; L_2, choke coil of 1,000 turns No. 24 enameled wire on a 2-inch form; C_1, mica condenser .002 mfd; C_2, variable condenser .00025 mfd; C_3, mica condenser .002 mfd; C_4, mica condenser .01 mfd; C_5, mica condenser .002 mfd; C_6, mica condenser .00025 mfd; C_7, mica condenser .004 mfd; T_1, filament transformer; T_2, transformer with secondary voltage 2,500 v.; R_1, resistor 5,000 ohms; R_2, rheostat 120 ohms for control of plate voltage. Vacuum tube oscillator is RCA 806.

than that of Chaffee and Light. The paired coils were energized in sequence, a mechanical switching arrangement being employed.

Both of these methods produced good results but had certain limitations. The subject had to be closely confined. If the cage in which

the animal was placed was increased in size over the minimum requirements for small subjects, really tremendous currents were necessary; this, in turn, necessitated elaborate and expensive switching apparatus to energize, successively, the coils in the three primary planes. In addition, the necessity of exciting the coils in sequence meant that when the implanted coil was in any of the three planes it received induced current only a third of the time. Moreover, while Chaffee and Light were able to change the frequency of the stimulating impulses, the wave form depended upon the condenser discharge.

We have modified the previous methods in two important respects: first, a current at high frequency is used to energize the primary coil, thus taking advantage of the greatly increased induction incidental to the increased rate-of-change of flux within the field and the resulting ability to use much smaller currents. Current at the frequency now used, 450 kilocycles a second, does not, of course, stimulate nervous tissue. But we have found it possible to rectify the current induced in the secondary coil by means of a very small copper oxide rectifying unit such as is used in instruments measuring alternating current. The current delivered to the stimulating electrodes depends for its characteristics, both as to frequency and wave form, on the modulation of the source of high frequency current energizing the primary coil.

Second, instead of using three primary coils, with the attendant difficulties of energizing them in sequence, it is now possible to construct a single unit for implantation consisting of three coils mutually perpendicular to each other, each with its individual rectifier, but all connected to the two stimulating electrodes. The entire unit has a diameter of 1½ inches and a maximum thickness of 5/16 inch. By this expedient the output at the electrodes is kept approximately constant regardless of the position of the animal.

The apparatus in operation at present consists of a simple vacuum tube oscillator, modulated at 60 cycles by the ordinary commercial current, which delivers approximately 150 watts at 450 kilocycles to a single coil of six turns of No. 14 insulated copper wire placed in the walls of a five-foot room. One or several animals may occupy this room, during stimulation, in relative freedom.

The strength of the field within the room is relatively constant, an output of 4.0 milliamperes being obtained from the implanted unit through an external resistance of 2,000 ohms, in the center of the room. A thorough trial, with a number of implantations with electrodes in contact with the cerebral cortex, skeletal and sympathetic pathways has shown this current to be more than adequate for stimulation.

The secondary unit is so adjusted that its resonant frequency is equal to that of the primary circuit. Since the frequency of the primary current may be varied by tuning this circuit, it is possible to implant two or more secondary units and to energize whichever is desired by tuning the primary to that particular frequency.

In summary, the apparatus here described makes it possible to stimulate nervous tissue in an animal that is free to lead a normal laboratory existence, for an extended period, with any wave form or frequency desired. More than one coil may be implanted and each may be stimulated at will. All materials required are readily obtainable and relatively inexpensive.

REFERENCES

1. Hess, W. R.: Beiträge zur Physiologie des Hirnstammes. Teil 1: Die Methodik der lokalisierten Reizung und Ausschaltung subkortikaler Hirnabschnitte, Leipzig, 1932, Georg Thieme.
2. Chaffee, E. L., and Light, R. U.: A Method for the Remote Control of Electrical Stimulation of the Nervous System, Yale J. Biol. & Med. **7**: 83, 1934.
3. Fender, F. A.: A Method for Prolonged Stimulation of the Nervous System, Am. J. Physiol. **116**: 47, 1936.

SOME ASPECTS OF ECHINOCOCCUS DISEASE

HAROLD R. DEW, F.R.C.S., F.A.C.S., PROFESSOR OF SURGERY,
UNIVERSITY OF SYDNEY, SYDNEY, AUSTRALIA

LIFE HISTORY

THIS disease is due to the development in the human subject of the cystic or larval stage of the *Echinococcus granulosus* (Batsch), a small cestode whose natural habitat is the small intestine of the dog. The adult worm measures up to 6 mm. in length and possesses three or four segments, the terminal one of which carries from 500 to 800 ova in various stages of development. These worms may be present in thousands in an infested dog, and the intact or disintegrated mature segments are shed in the feces.

The ova, approximately 35 μ in length, are, like those of the other cestodes, surrounded by a chitinous envelope and are extremely resistant to exposure. Under favorable etiologic conditions, they may be ingested by the correct intermediate host in which the cystic stage of development takes place.

ETIOLOGY AND PROPHYLAXIS

Although the worm has been occasionally found in other canines, owing to his cosmopolitan distribution and close association with man, the dog is practically the only source of infestation. This animal is infested by eating fertile hydatid cysts in the viscera of animals which can act as intermediate hosts, nearly always the domesticated sheep, ox, or pig. It is found that the incidence of the disease in man follows accurately that in the domestic animals of the country and that the sheep is the most important intermediate host. For this reason the disease is common in Iceland, Australasia, Algeria, and South America. It is rare in North America, although many sheep are pastured there. It would seem, however, that if a close association persists between men, dogs, and sheep, the disease will gradually increase in frequency there.

Man acts only as an immediate host, occupying the same biologic position as the sheep; but owing to the fact that dogs do not have access to human viscera, such infestations must be considered as a dead end as regards completion of the parasitic life cycle. In the past, great importance has been attached to the contamination of water or fresh vegetables as an etiologic factor, but there is no doubt that con-

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tamination of the hands by direct contact, i.e., by handling and caressing dogs, is far more important. This explains the relatively high incidence in various occupations, the frequency of more than one case in a family, the almost equal incidence in the two sexes, and the frequency of infestation during childhood, the age of promiscuity with the dog and unhygienic behavior generally. One must realize that the majority of infestations occur in childhood, although owing to the slow growth of the cyst, the disease often does not manifest itself until adult life. It may be taken as a general rule that an hydatid cyst in man is nearly as old as the patient harboring it.

Owing to the existence of two distinct evolutionary cycles in the life of the parasite, prophylactic measures are easy and should be applied in two ways: first, by preventing infestation of the dog by controlling his access to infested viscera; and second, by educating people concerning the danger of contact with possibly infested dogs.

DEVELOPMENT OF THE CYST

Following ingestion by the intermediate host, the ovum hatches in the upper alimentary canal, liberating an active six-hooked embryo, which bores through the wall of the gut and, entering a radical of the portal vein, is carried to the liver where in the majority of cases it comes to rest and where its typical further development is seen. At first there is an active cellular reaction on the part of the host defences—mononuclear and eosinophil cells surrounding the parasite which may then undergo disintegration and phagocytosis. In favorable cases, however, it grows rapidly and with the same dramatic changes that characterize all embryonic growth, so that at the end of three weeks it shows vacuolation with the elaboration of specific fluid and a protective outer wall.

As the parasite grows, the cellular reaction to the host dies down, probably coincident with the development of the semipermeable, laminated, parasitic cuticle, and so the cessation of leakage of specific protein. The leucocytes which surround the follicle become gradually converted into fibroblasts, and toleration of the parasite by the host is established.

The fully developed cyst consists of a double layered parasitic wall composed of an outer laminated membrane and an inner germinal layer surrounding specific hydatid fluid.

The laminated layer is composed of lamina of hyalin which are laid down from within out by the nucleated germinal membrane which lines its inner aspect. It is very elastic, tends to turn inside out when torn, and serves to act as a support for the cyst, and, owing to its selective permeability, prevents the entry of noxious substance. The specific hydatid fluid is also elaborated by the germinal mem-

brane and normally is clear, containing little or no protein, but up to 0.2 per cent sodium chloride. It acts as a buffer and nutritive medium for the developing scolices.

The scolices or future worm heads are found only in mature cysts and are a sign of completed biologic development. They are produced inside brood capsules from the germinal membrane and may be present in thousands in a single cyst, a fact which gives some idea of the prodigality of nature where reproduction is concerned. They are just visible to the naked eye (measuring up to 160 μ in the rest-

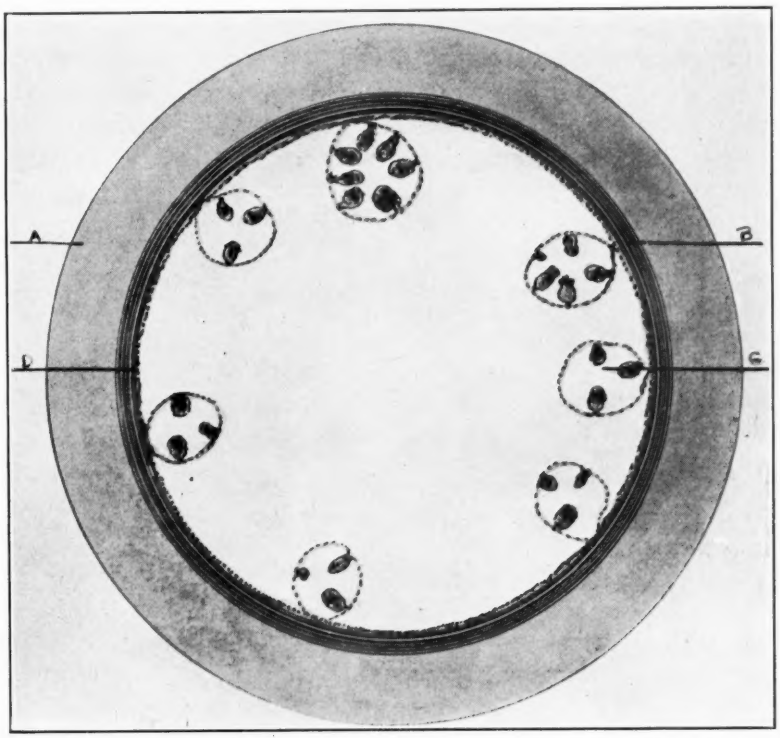

Fig. 1.—Schematic representation of a typical unilocular hydatid cyst, showing *A*, adventitia; *B*, laminated membrane; *C*, germinal membrane; and *D*, brood capsules containing scolices.

ing state) and are seen in all stages of development—from the undifferentiated cellular bud to the fully developed scolex with suckers, hooklets, and contractile tissue. When swallowed by the dog, they become active and rapidly develop into adult worms, and so the life cycle is completed.

Frequently in man and occasionally in other animals, daughter cyst formation is noticed. This in its typical endogenous form consists of the development within the confines of the original mother cyst of numerous replicas of the primary cyst. There has been much controversy as to the reason for this development, but probably it should be regarded as due to some interference with the integrity of the

original cyst; i.e., that it is a protective phenomenon, the germinal elements being stimulated by adverse conditions to elaborate a second protective cuticle in order that the development of the reproductive elements may go on.

CLINICOPATHOLOGIC CONSIDERATIONS

In man the majority of primary cysts are found in the liver, this organ acting, as it were, as a filter; but sometimes the parasite passes the hepatic capillaries and enters the pulmonary circulation, the lungs being the next most common site. The parasites may even pass the pulmonary capillaries and make their way to any part of the body, and the lessening proportionate incidence, as the periphery of the body is reached, indicates that distribution by the blood stream is the only rational explanation. The following table gives the commonly accepted figures for primary cysts:

DISTRIBUTION OF PRIMARY HYDATID CYSTS

Liver	76.6
Lung	9.4
Muscular and subcutaneous tissue	5.2
Kidney	2.3
Spleen	2.1
Bones	0.9
Orbit	0.7
Brain	0.6
Other sites	2.2

Multiple infestations are more common in the human subject than is usually realized, more than one cyst being present in at least 60 per cent of cases.

UNCOMPLICATED CYSTS

From both the clinical and the pathologic point of view, cysts may be divided into complicated and uncomplicated cysts. It is important to realize such is the latency of many cysts that it is often only the onset of some complication which produces the first symptoms and so draws attention to the lesion.

Uncomplicated cysts comprise all the simple univesicular cysts and some multivesicular (containing daughter cysts) cysts, which have remained noninfected and intact. The simple cysts are found typically in children and young adults; the multivesicular, in older patients; and all are surprisingly well tolerated. This is due to their extremely slow rate of growth, which enables compensatory changes to occur, and to the fact that the cyst is shut off from the body fluids of the host by a relatively impermeable fibrous and laminated layer.

UNCOMPLICATED HEPATIC CYSTS

The right lobe is involved in 80 per cent of the cases and the cysts project on the abdominal aspect in 70 per cent of the cases. Clini-

cally, the outstanding feature is the latency and many cases have been recorded in which enormous cysts have existed for years without causing symptoms. This is particularly the case with cysts of the upper quadrants, where the protected site enables them to grow quietly, very often until middle age, without causing obvious symptoms.

Pain in these cases is very rare, and when it occurs it is nearly always indicative of the onset of some complication such as leakage with or without infection. Gastric disturbances which appear to be due to pressure effects are common in long-standing cysts, but they are as a rule vague and not serious. Other pressure effects are sometimes seen and depend on the site and the size of the cyst; it is surprising what very large cysts may be tolerated. In cases in which the cyst exerts pressure on the diaphragm, some dyspnea may be produced. Examination may reveal a rounded, nontender, tense, cystic swelling continuous with the liver dullness. The swelling moves with respiration, but has to be distinguished from other lesions of the right hypochondrium. It is important to realize that cysts of the left lobe of the liver tend to descend anterior to the stomach, while those of the right lobe tend to be on a more posterior plane. In centrally or superiorly placed cysts, the only finding may be hepatomegaly with varying degrees of upward extension of hepatic dullness. In these cases which tend to appear in older subjects, the elevation of the diaphragm may be extreme and the simulation of intrathoracic conditions very accurate.

Radiography is of value in the diagnosis of these cysts, because it may show diaphragmatic elevation or distortion or in older cysts some calcareous changes in the adventitia.

UNCOMPLICATED PULMONARY CYSTS

Owing to the vascularity and loose nature of the tissue, pulmonary cysts grow evenly and fairly rapidly, producing as a rule a relatively thin adventitious covering. The typical cyst is univesicular, containing scolices but no daughter cysts, and it may occupy a parabronchial or peripheral situation, sometimes almost filling the chest cavity. Even in the case of large cysts, pleural adhesions are rare. The bases of the lungs are involved more than the upper parts and the right side more than the left in the proportion of 60 to 40.

Clinically, these cysts are also remarkably latent, and it is doubtful whether more than 25 per cent are discovered before the onset of some complication. Sometimes the first indication of their presence is delay in resolution of some respiratory infection like bronchitis or pneumonia. A dry cough is classical and common and seems to be independent of the size or site of the cyst. Hemoptysis is the most common symptom, being present at some time or other in 60 per cent of cases and varying greatly in degree. There is, as a rule, no ex-

pectoration and no pain and little if any dyspnea, even in large cysts.

On physical examination, palpation rarely reveals any cardiac displacement, even in large cysts. There will be diminished vocal fremitus over any area impinging on the chest wall, and further examination may reveal the signs of local tumor with appropriate signs on auscultation.

THE DIAGNOSIS

Phthisis is the arch simulator, but the basal situation of the lesion and the lack of confirmatory signs of tuberculosis usually lead to its

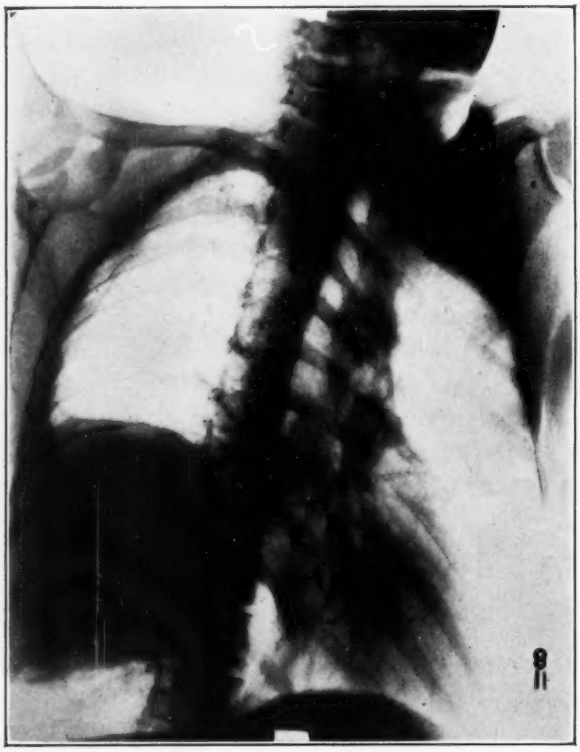

Fig. 2.—Radiograph of unruptured, right-sided pulmonary cyst in a patient aged twenty-four years. Oblique view.

exclusion. Radiography, owing to the fact that the saline content of the cyst is relatively radiopaque, has revolutionized the diagnosis of these cases, and great accuracy both as regards the size and localization of the cyst is now possible (Fig. 2). It is, of course, necessary to exclude all other forms of intrathoracic tumor, while the presence of a pleural effusion may at times introduce difficulties in the region of the diaphragm.

OTHER SIMPLE CYSTS

Uncomplicated cysts may involve practically any organ or any tissue, and as a result bizarre and protean manifestations may be produced.

Small cysts in special situations such as the orbit, cranial cavity, or spinal canal may produce grave symptoms relatively early.

COMPLICATED CYSTS

Ultimately, however, in all the above, no matter what the situation, complications occur, their frequency increasing as age advances and the cyst increases in size. They are relatively rare in young subjects, manifesting themselves usually between the ages of twenty-five and forty years of age. Practically all complications depend on an escape of fluid from the cyst, this varying from a slight leak, often masked by other symptoms, to a frank rupture.

RUPTURE OF THE CYST

As the cyst enlarges, it may encroach on a natural channel, a hollow viscus or serous cavity, one area of the laminated membrane thus becoming relatively unsupported. As a result it gives way spontaneously, even during sleep, following muscular movement, coughing, straining, or more commonly following direct trauma such as a blow, a fall, a crush, or a perforating injury. Owing to its peculiar grain, the tear in the laminated membrane rapidly enlarges and allows the escape of the contained fluid and hydatid elements. Such rupture takes place commonly into the subcutaneous or muscular tissues, the bile ducts, bronchi, alimentary canal, or urinary tract; into serous cavities, such as the peritoneum, pleura, or pericardium; or very rarely into the chambers of the heart or large veins.

Each of these has its own characteristics, and as some of them may be combined in the individual case, a complete discussion is outside the scope of this article. The sequelae may be grouped together in the following way:

1. *General:* applicable to all types: (*a*) immediate, hydatid anaphylaxis; (*b*) delayed, secondary echinococcosis.

2. *Special:* applicable to cases of rupture into a natural channel: (*a*) immediate, mechanical effects; (*b*) delayed, death of the cyst with or without suppuration.

HYDATID ANAPHYLAXIS

Many clinicians have noted the appearance of peculiar toxic manifestations following rupture or puncture of hydatid cysts. Although these are usually cutaneous, many other symptoms may occur, and there is no doubt that these are mainly anaphylactic, due to the sudden absorption of specific protein in a sensitized patient. Clinically, whenever vague symptoms arise during the course of hydatid disease, the question of whether or not they are anaphylactic in nature should always be considered. The following table gives some idea of their protean nature and illustrates some of the risks of indiscriminate puncture of an hydatid cyst.

ANAPHYLACTIC SYMPTOMS IN TWENTY CASES OF HYDATID DISEASE

SITE OF CYST	COMPLICATIONS	CASONI TEST	DYSPNEA	COUGH	CYANOSIS	CARDIAC	AGITATION	PYREXIA	URTICARIA	PRURITUS	VOMITING	DELIRIUM	PULMONARY EDEMA	DILATED PUPILS	DEATH	REMARKS
Liver	Bile duct rupture	?	+	+	+	+	+	+ D*	+ D	+	+	−	−	+	−	Three attacks
Heart	Rupture	?	+	+	+	+	−	−	−	−	−	+	+	+	+	
Lung	Cardiac rupture	?	+	+	+	+	−	−	−	+	−	−	+	+	+	
Spine	Rupture of daughter cysts	+	−	+	−	+	−	+	+	+	−	−	−	−	−	Repeated postoperative
Liver	Bile duct rupture	+	+	+	+	+	+	+	−	+	+	−	−	−	−	Many previous operations
Liver	Bronchial rupture	+	+	−	−	−	−	−	+	+	−	−	−	−	−	In convalescence
Liver	Casoni test	+	+	+	+	+	+	+ D	−	−	+	+	+	+	−	Very small dose
Lung	Rupture into pulmonary artery	?	+	+	+	+	−	−	−	+	−	−	−	+	+	
Liver	Peritoneal rupture	?	+	+	−	+	+	−	+ D	−	−	−	−	+	−	
Liver	Pleural rupture	?	+	−	−	+	+	+ D	−	+	+	−	−	−	−	Postoperative
Liver	Biliary rupture	?	+	−	−	+	−	+	+	+	+	−	−	+	−	
Liver	Pleural rupture	?	+	+	+	−	+	+	+ D	+	−	−	+	−	−	Postoperative
Liver	Bile duct rupture	?	−	−	−	−	+	+	+	+	+	−	−	−	−	
Lung	Pneumothorax	?	+	+	+	+	+	+ D	+ D	+	−	−	+	−	−	
Omentum	Rupture	?	+	−	+	+	+	+	+	−	+	−	−	−	−	Many previous operations
Pelvis	Leak	?	+	+	−	+	−	−	+ D	+	−	−	−	−	−	
Omentum	Leak	?	+	+	−	+	+	+	+ D	+	+	−	−	−	−	
Liver	Postoperative	+	−	−	−	+	−	+ D	+ D	+	−	−	−	−	−	After eight days
Liver	Peritoneal rupture	+	−	+	−	+	−	++	−	−	−	+	−	−	−	Postoperative symptoms
Liver	Puncture	?	+	−	+	+	·	−	+ i.m.	+	+	−	−	−	−	

*D = delayed reaction; i.e., after 12 hours.

SECONDARY ECHINOCOCCOSIS

Rupture of an hydatid cyst or puncture by a trocar with evacuation of the specific fluid does not necessarily cause the death of the parasite; this probably rarely occurs unless infection takes place. The parasitic elements have such powers of persistence that if aseptic conditions pertain they can survive and ultimately develop into new cysts, often at a distance from the original, this phenomenon being described as secondary echinococcosis.

At first, clinicians and pathologists regarded all cases of multiple cysts as due to multiple primary infestations, but they gradually recognized that many were due to secondary cyst formation from implanted scolices. Even as late as 1900, however, the view that such highly differentiated structures as scolices could, as it were, revert in their life cycle, ranked with many authorities as a biologic heresy, as it seemed contrary to all the laws of the development of the cestodes laid down by Van Beneden. Much experimental work and many correlated clinical and pathologic investigations, however, have proved conclusively that such a retrogressive metamorphosis is not only possible, but relatively common and of great clinical importance. Recognition of this has led to great advances in our understanding of the pathology of hydatid disease.

CLINICAL TYPES

Localized Secondary Echinococcosis.—A common example of this is rupture of a subcutaneous or muscular cyst when congeries of small secondary cysts, often called seed hydatids, are commonly found. Of a similar nature are those cases of postoperative or posttraumatic recurrence in the site of the original cyst; one type of local daughter cyst formation.

SECONDARY CYSTS OF THE PERITONEUM AND PELVIS

These are very common and are due to leakage of scolices from a primary cyst of the liver or, more rarely, of the spleen, kidney, or omentum.

When the cyst ruptures, hydatid scolices are shed into the peritoneal cavity with the production of some anaphylactic shock. The scolices may be shed in thousands and are carried by the rush of fluid, by gravity, or by intestinal movement, as a rule to the lower quadrants. They soon become surrounded by lymph and eosinophil leucocytes and are rapidly fixed in a secondary site. Doubtless many of them are overwhelmed and undergo fibrosis; sometimes the peritoneal reaction around these disintegrating scolices is so extensive that a pseudotuberculous appearance is produced. Many, however, survive, become surrounded by a new adventitia, undergo vesiculation, and

develop into secondary cysts. As in the case of any other foreign body, the peritoneum gradually spreads over until the secondary cyst gives the appearance of having developed in an extraperitoneal situation. It was nonrecognition of this simple process that led many of the older pathologists to believe that these cysts were multiple cysts developed from numbers of hexacanth embryos.

These secondary cysts are of slow growth, there being a latent period of from five to twelve years during which growth takes place until they in their turn produce symptoms. Owing to the usual rapid recovery from the initial rupture, it is often misinterpreted by the clinician, and its true significance is unrecognized until at a later date the discovery of multiple abdominal cysts leads to a retrospective diagnosis. It is thus not uncommon for rupture of a visceral cyst to occur in youth, but for its clinical manifestations and recognition in the form of multiple abdominal cysts to be delayed until adult age is reached. Secondary abdominal cysts are always multiple, often irregular in shape and size, and owing to the relative tenuity of their adventitia, are prone to further ruptures with repetition of the above effects. As a result, the peritoneal cavity may become filled with hydatid cysts in all stages of development, a very grave condition aptly described as hydatidosis.

Usually the rent of the primary cyst becomes occluded by adhesions, and the residual germinal elements produce multiple daughter cysts, one type of localized secondary echinococcosis. It is a general rule that when multiple peritoneal cysts are found there is also a primary visceral cyst containing daughter cysts. Sometimes, of course, owing to the presence of a communication with a bile duct, intraperitoneal rupture of an hepatic cyst gives rise to leakage of the bile into the peritoneal cavity with the production of a choleperitoneum, often a puzzling condition.

Secondary cysts may also occur in the pleura or pericardium following rupture of a pulmonary or cardiac cyst.

Metastatic Secondary Echinococcosis.—This gives rise to the rarest but the most interesting type of all secondary cysts and is due to a rupture of a fertile simple cyst into the heart or venous system. The rupture may take place on the venous side of the circulation into peripheral veins or the right cardiac chambers, or into the arterial side when it takes place into one of the left cardiac chambers. Two sets of sequelae are possible. In both, of course, grave anaphylactic symptoms occur, although as a rule recovery from the primary rupture takes place. If the cyst ruptures into the venous side of the circulation, the scolices are carried through the right ventricle into the lungs, where they are filtered out and give rise to secondary pul-

monary cysts. These cysts are characterized by their multiplicity, their bilateral and peripheral distribution, and by their uniform size.

In the case of rupture into the left auricle or ventricle, the hydatid elements enter the systemic circulation and give rise to metastatic cysts in various parts of the body. Owing to the position and relative size of the carotid arteries, the majority of scolices are carried to the brain, which becomes the seat of the majority (60 to 70 per cent) of these secondary cysts. Some scolices, however, may escape

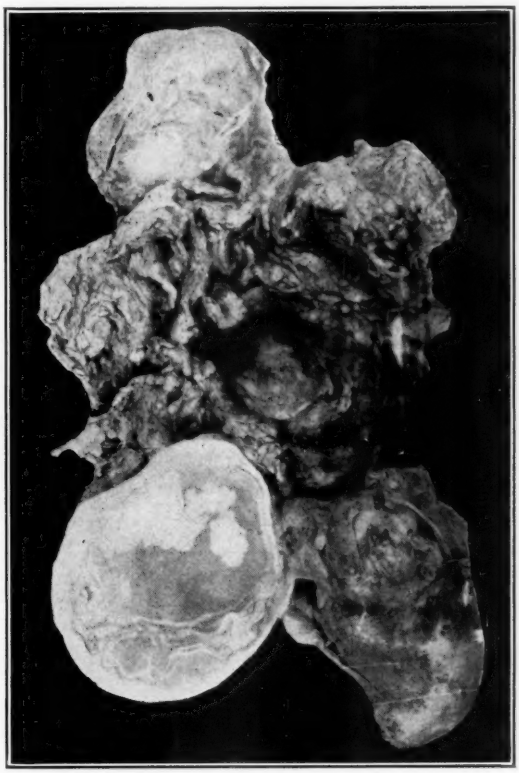

Fig. 3.—Multiple secondary cysts of the omentum, following intraperitoneal rupture of an hepatic cyst.

into the kidney, spleen, or liver. All these are simple cysts of approximately the same size, rarely becoming larger than a hen's egg.

These examples illustrate the classical manifestations of secondary echinococcosis, which is now clearly established as regards its etiology, pathology, and clinical aspects. It is a general rule, in the case of multiple cysts, that if the extrahepatic cysts are more than one-third of the total it is probable that they are secondary cysts.

MECHANICAL EFFECTS OF RUPTURE

The mechanical effects of rupture of a cyst are seen in cases of rupture into a natural channel. Following the initial flooding, which is

rarely serious, the passage of hydatid products along the channel leads to attacks of colic or intermittent, partial, or complete obstruction. These are immediate effects, although they may continue for months as fractional evacuation of the cyst contents occurs.

Microorganisms do not find their way through an intact laminated membrane, and in the case of simple cysts some degree of rupture of this membrane is an essential preliminary to suppuration. Once the hydatid membrane collapses, however, some serum is exuded into the cavity, and with hydatid débris makes such an excellent pabulum for the growth of microorganisms that when contact with a lining epithelium is made infection usually occurs. Small ducts may, however, open into the cavity, and yet it may remain aseptic for years, and occasionally actual repair of the opening may occur. Obviously the time that elapses between rupture and infection depends on a great number of factors, so that although infection may coincide with the rupture, it is sometimes delayed for weeks or months.

Fig. 4.—Multiple metastatic cysts of the brain, following left intracardiac rupture of a primary cardiac cyst.

Rupture of Hepatic Cyst Into the Biliary Passages.—As an hepatic cyst continues to enlarge, it often causes a quiet pressure necrosis of the wall of a large bile duct, and if the opening becomes large enough, some of the contents are forced into the duct. Such ruptures are relatively common, and I believe that some degree of intrabiliary rupture is the commonest complication of hepatic cysts. It may be a

quiet leak with the passage of fluid and small particles of débris, or a frank massive rupture with or without occlusion of the main ducts with daughter cysts. This rupture takes place most commonly in the intrahepatic portion of the ducts, the passage of material down the ducts being helped by intracystic pressure, diaphragmatic movement, and abdominal muscular action; and once started, the slippery, nonirritating membrane is helped on by the increased biliary flow after meals (Fig. 5).

In this way fractional evacuation of the cyst may take place into the duodenum. As is to be expected, this condition simulates complicated cholelithiasis very closely, this being the common diagnostic error. The following points are of interest in the differential diagnosis:

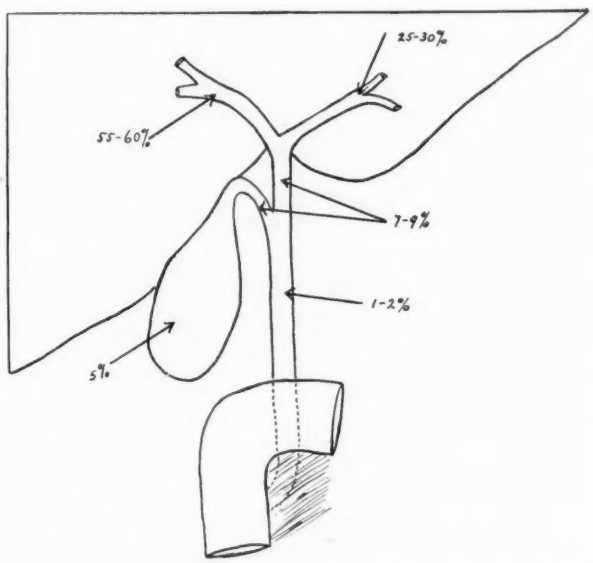

Fig. 5.—Figure showing sites of rupture of hepatic cysts into the biliary passages.

Age.—Hydatid disease tends to occur at a slightly younger age than stone in the common duct; i.e., thirty to forty years rather than forty-five to fifty-five years.

Sex.—In hydatid disease, males are affected as commonly as females; whereas, gallstone disease affects females four times as commonly as males.

Pain.—The pain of hydatid disease is not so severe as true gallstone colic.

Previous History.—In gallstone disease there is usually a long history of flatulence, etc.; this is often completely absent in hydatid disease.

Examination of the Stools.—Examination of the feces by washing should be used as a routine in all cases of jaundice. In hydatid disease the tough, bile-stained, laminated membrane, which resists putrefaction, is often discovered.

Hepatomegaly.—This is much commoner in hydatid disease than in cholelithiasis.

Jaundice.—A characteristic of hydatid disease involving the ducts present in 80 to 90 per cent of the cases. In gallstone disease gross persistent jaundice is rare and is practically confined to cases of stone in the common duct.

Radiography.—This should be applied as a routine, as it may indicate subdiaphragmatic distortion or calcareous change in a cyst.

Immunological Reactions.—These are of the utmost value. The use of the hydatid complement fixation test and the intradermal test of Casoni has revolutionized the diagnosis of hepatic hydatid in Australia.

HEPATOBRONCHIAL FISTULA

Hepatobronchial fistula is not uncommon and is due to rupture through the right diaphragmatic cupola by way of adhesions into the bronchus with or without pleural infection. The patient first expectorates daughter cysts and bile-stained débris, and later foul-smelling pus. All sorts of other complicated pictures due to other coexistent ruptures may occur, and unless the surgeon is alive to the vagaries of hydatid disease, mistakes in diagnosis, treatment, and prognosis are inevitable.[1]

OTHER TYPES OF RUPTURE

Rupture into the alimentary canal may also occur, occasionally with natural cure, although as a rule suppuration causes a rapid, grave alteration in the picture. Rupture into the urinary passage may occur in the case of renal or pelvic cysts with a close simulation of renal colic. This, too, is prone to infective sequelae.

Rupture of a Pulmonary Cyst Into a Bronchus.—This is the natural end of most pulmonary cysts, because by the time a cyst reaches a diameter of four to five inches it nearly always comes into contact with a large bronchus, the erosion of which causes a small part of the cyst wall to become unsupported. Following a cough, a muscular effort, an injury, or even spontaneously, the cyst wall gives way and the contents enter a bronchus. Rarely the patient is asphyxiated by the fluid or by the impaction of membrane in the glottis. More usually the dramatic symptoms are anaphylactic in nature.

After rupture the patient usually recovers rapidly, although for some time repeated expectorations of fluid and gradual evacuation of the cyst contents may occur. The patient may have attacks of coughing and hemoptysis, but remain afebrile and in good health throughout. Natural cure depends on the size of the cyst, as on it will depend the

thickness of the adventitia and the possibility of complete collapse and the time taken for disintegration and expectoration of the cyst wall. As is to be expected, small cysts and cysts in children more readily undergo natural cure. The larger the bronchial communication and the more dependent its position, the better are the chances of evacuation. Apical cysts are more likely to involve bronchi while yet small, and the opening will probably be dependent, facilitating drainage. Deeply placed parabronchial cysts also fulfill most of these conditions, and all are agreed that these should not be attacked surgically and that, if left alone, about 70 per cent will undergo natural cure. In some cases the cyst remains uninfected for long periods,

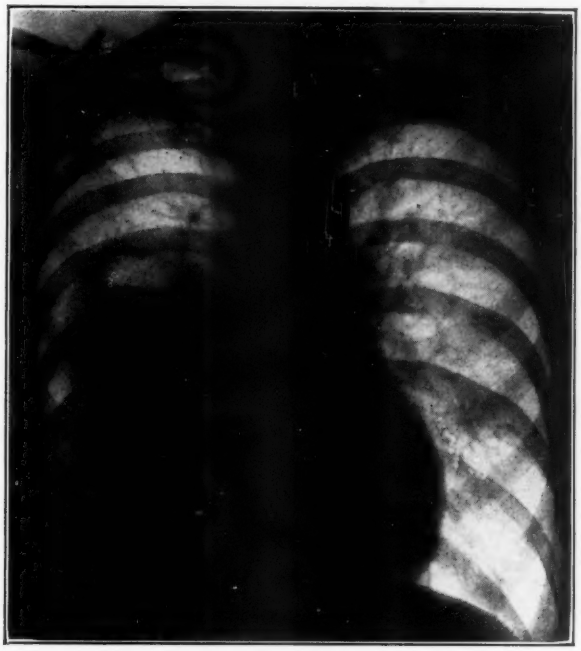

Fig. 6.—Echinococcus cyst of the right lung after rupture into a bronchus, showing hydatid pneumocyst.

while in others the presence of a fluid level with gas alone—hydatid pneumocyst—gives a very characteristic radiographic appearance (Fig. 6).

In a great many cases the cavity becomes infected, at first with saprophytic, but later with pathogenic, organisms, at first of low virulence, but later with virulent cocci and often anaerobic gas producers. The adventitia becomes thickened and lined on the inner aspect with a pyogenic membrane, and the clinical picture becomes one of intrapulmonary abscess, which necessitates surgical intervention.

Hydatid Pneumothorax.—Another interesting type of rupture is that of a subpleural pulmonary cyst into the pleural cavity. This may be

comparatively quiet, with immediate anaphylactic symptoms or the formation later of secondary pleural cysts.

As a rule, however, the subpleural cyst is large enough to have also involved a patent bronchus, in which case a pneumothorax follows. Hydatid pneumothorax, occurring as it does in a previously healthy patient, may be most dramatic. At first the effect is mechanical, although the mild irritation of the pleura often leads to a hydropneumothorax. In the majority of cases, however, infection leads to a pyopneumothorax.

This condition may be confused with tuberculous pneumothorax, but unlike that disease it is common in adolescents, more common on the right side; there is rarely any suggestive previous history; no signs are present on the opposite side; tubercle bacilli are absent from the sputum; anaphylactic symptoms are common; and the typical hydatid immunologic reactions are often positive.

Death of the Parasite.—Following aseptic rupture into a natural channel and occasionally apparently from unknown causes, the parasitic fluid may be evacuated or absorbed, the parasite dies, and a collection of inspissated material containing cholesterin, fatty acids, calcium salts, and crumpled hydatid membrane is left. This becomes enclosed by fibrous tissue which contracts and often shows calcareous deposition. Such dead cysts are not infrequently found at autopsy.

Suppuration.—Suppuration is a constant risk in all cases in which rupture into a natural channel has taken place. This is particularly prone to occur in the cysts which have ruptured into the bronchi or the biliary passages. It may be for long delayed, but unless complete evacuation through a relatively dependent opening takes place, the hydatid débris and serum make such an excellent pabulum for bacterial growth that suppuration is always likely to occur. When it does, the patient exhibits signs and symptoms typical of an abscess of the region involved, with a rapid alteration of the clinical picture.

DIAGNOSTIC METHODS

Radiography has revolutionized the diagnosing of intrapulmonary cysts, since the saline cystic contents are relatively opaque and give a characteristic shadow. In subdiaphragmatic cysts, elevation of the diaphragm is a very striking feature and can often be detected. Calcareous changes in the adventitia are also often noted in the case of abdominal cysts. Routine x-ray examination alone, however helpful it may be in pulmonary cases, often fails in young subjects with cysts of a moderate size; and in Australia this method of examination is always supplemented by immunologic methods. The precipitin test, as utilized by Fleig and Lisbonne, has given way to the complement fixation test as modified by Fairley,[2] using fresh hydatid fluid from sterile sheep cysts as antigen. In addition, the intradermal

test of Casoni has in our hands proved itself of the utmost value.[3] By the combined use of these methods, 90 per cent of hydatid cysts are now confidently diagnosed.

TREATMENT

Simple Uncomplicated Cysts of the Liver.—As a rule general anesthesia is indicated as there seems to be some risk of anaphylactic shock, if by chance fluid is spilled and absorbed, when local anesthetic is used. The incision should be made to give the most direct approach. In the case of cysts of the upper quadrant, the transcostal route must be used, but in order to lessen the ever present risk of pleural contamination, the incision should be made as far forward and as low down as possible to avoid the pleura. If this cannot be done, a two-stage procedure with preliminary packing to produce adhesions is advisable.

The field should be well packed off and it is important to realize that scolices spilled into the wound may implant and recur; in other words, the cyst must be treated as an infective focus. Guy sutures should be inserted, and after partial evacuation with a needle, commercial formalin should be injected in sufficient quantity that when mixed with the fluid of the cyst it will form a 2 per cent solution. This, if allowed to act for three or four minutes, will sterilize the scolices and the cyst can then be widely opened and evacuated with the pump. If daughter cysts are present, it is impossible to sterilize the contents with formalin, but this should be used after evacuation to swab out the cavity and so kill any free scolices. After evacuating and cleaning the cavity, the procedure varies with the state of the cyst. If clean, it should be filled with saline solution and closed completely without drainage. If full of débris, if bile stained, or if there is any suspicion of infection, it should be partly sutured and drained by a wide tube using omentum if possible to protect the suture line and the tube.

Cysts which have involved the biliary passages introduce difficult problems depending on the pathologic condition found. If there is obstructive jaundice, the common duct must be opened and the hydatid débris evacuated while the offending cyst must also be found, and as there is nearly always infection present, both it and the ducts must be drained.

Suppurating cysts in the liver must be treated by open drainage in exactly the same way as hepatic or subphrenic abscesses, both of which conditions it may simulate.

For fuller details of the various problems in the treatment of these cases, reference should be made to references 4, 5, and 6.

Pulmonary Cysts.—Parabronchial cysts which are normally small and inaccessible and which from their position have an excellent chance

of natural cure by expectoration through a bronchus should be left alone unless some complication such as persistent infection occurs.

All peripheral cysts should be operated upon, because complications such as intrabronchial or intrapleural rupture are, owing to the impossibility of natural cure and to the spread of infection, much more dangerous. As a rule in clean cases there are no pleural adhesions, and the ever present risk is that of pleural soiling. In these cases a two-stage operation with preliminary excision of part of the chest wall after careful localization and tamponade for twelve days, followed by incision, evacuation, and drainage, is a safe and eminently satisfactory procedure. This may be performed under local or general anesthesia with the patient in such a position as to lessen the risk of sudden bronchial flooding, a risk which is always present. Positive pressure intratracheal anesthesia can also be used in these cases, but calls for some manual dexterity in putting in holding sutures to prevent pleural soiling, and close cooperation with the anesthetist who must expand the lung to obliterate the pleural cavity. All of these cases should be drained by means of a wick of rubber tissue for a few days to obviate the risk of surgical emphysema or valvular pneumothorax.

In cases of intrabronchial rupture there is always some degree of infection and the risks of pleural contamination are greatly increased. These should be treated as one would a pulmonary abscess, and after careful localization a two-stage operation is always advisable.

For a fuller discussion of these and allied problems the reader is referred to reference 1.

I am indebted to the editor of the Medical Journal of Australia for permission to reproduce Figs. 1, 3, 4, and 5.

REFERENCES

1. Dew, H. R.: Hydatid Disease, Sydney, 1928, Australian Medical Publishing Co., p. 430.
2. Fairley, N. H.: Complement Fixation in Hydatid Disease, Quart. J. Med. **15**: 224, 1922.
3. Dew, H. R., Kellaway, C. H., and Williams, F. E.: The Intradermal Reaction in Hydatid Disease and Its Clinical Value, M. J. Australia **1**: 471, 1925.
4. Ibid.: Reference 1, page 209.
5. Dew, H. R.: Operative Treatment of Hydatid Cysts of the Liver, Surg., Gynec. & Obst. **48**: 239, 1929.
6. Carrodus, A. L.: Intrabiliary Rupture of Hydatid Cysts of the Liver, M. J. Australia **2**: 714, 1935.

MALIGNANT TUMORS OF THE THROAT

CHARLES L. MARTIN, E.E., M.D., F.A.C.R., DALLAS, TEX.

(From the Department of Radiology, Baylor Medical School)

IN SEPTEMBER, 1931, Henri Coutard[1] presented before the American Roentgen Ray Society a résumé of his excellent results obtained with the roentgen treatment of epitheliomas of the tonsillar region, hypopharynx, and larynx at the Curie Institute in Paris. His method was radically different from those previously used in this country since he advocated the administration of doses to the sides of the neck and the deep tissues of the throat equal to five or six times those formerly thought to be safe for the normal tissues. Severe reactions consisting of desquamation and ulceration of the superficial structures both inside and outside the pharynx were obtained, but when the massive doses were properly fractionated and given in small daily amounts over periods of three to five weeks, prompt healing of the roentgen sequelae occurred, and in many instances the malignant tumors melted away never to recur. Good results had been obtained in the United States with radium, but its proper application, particularly in the more inaccessible lesions, was difficult and often impossible and the simpler, more efficient x-ray technique was welcomed by American radiologists.

PATHOLOGY

For the sake of simplicity, malignancies of the throat will be designated in this paper as tumors of the pharynx, including those arising from the soft palate, the tonsils, base of the tongue, lateral pharyngeal walls, pyriform sinuses, edges of the epiglottis, and upper margins of the larynx; and intrinsic tumors of the larynx, including those arising from the ventricular folds, vocal cords, arytenoids, and walls of the larynx below the vocal cords. All of these neoplasms are particularly well suited for radiation therapy because their radiosensitivity in most instances exceeds that indicated by the histologic picture. In 1927, Quick and Cutler[3] described the marked radiosensitiveness of transitional cell carcinoma of the pharynx, and in 1929, Ewing[2] indicated that lymphoepithelioma responded even better. Martin and Pflueger,[4] after carefully studying a mixed group of cases, found that epidermoid carcinomas and even adenocarcinomas of the pharynx could be eradicated with doses much smaller than those needed for similar lesions in other portions of the body, and the ready response of lymphosarcoma has been known for years. Caldwell[5] and others feel that reticulum cell sarcoma, a very rare

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tumor in the throat, should not be included in the lymphosarcoma group, but from the clinical point of view the treatment and results are identical. Clerf and Crawford[6] have shown that 98 per cent of the intrinsic malignant neoplasms of the larynx are squamous cell carcinomas. The remainder are usually adenocarcinomas, and it has been our experience that both of these types can be favorably influenced with relative ease. Although most of the tumors just enumerated can be graded according to Broder's classification, Cade,[7] Cutler,[8] Garland,[9] and Martin[10] have independently observed that their response does not correspond to their theoretical radiosensitivity based on the histologic findings; and Quick[11] has especially emphasized the fact that two tumors having exactly the same appearance under the microscope may react differently to identical doses of radiation. In no other portion of the body is one so strongly impressed with the fact that prognosis should never be based on the microscopic report alone.

METHOD OF TREATMENT

When the value of radium was first recognized, it was placed in thin-walled steel needles in rather large quantities and the needles were inserted into the diseased tissue for varying periods of time. When efficient doses were used, painful sloughs were likely to occur and carcinoma often continued to grow outside the treated areas. Surface applications were also made with radium plaques and capsules, but it was found difficult to control the deeper extensions of the disease in this manner. As a result of much experimentation, Regaud and his collaborators at the Curie Institute elaborated certain principles which served to markedly increase the efficacy of irradiation. It was their observation that the least damage resulted in normal tissues and that the rays showed their greatest selectivity for malignant cells when very low intensities, short wave lengths, and relatively long periods of continuous treatment were utilized. In this country an attempt was made to carry out these principles by inserting small bits of capillary glass tubing containing radon directly into the tumors. Since the radon rapidly lost its power to emit rays, it was found safe to leave these small foreign bodies in place. However, the glass possessed very little filtering power, and although the intensity was low and the time of treatment prolonged, the long wave lengths passing through the glass produced many painful sloughing reactions. In 1926, Failla[12] described similar implants made from capillary gold tubing having a wall thickness of 0.3 mm. which served to remedy this fault to a large extent. These applicators are very small and can be inserted through specially constructed trocars into most of the growths occurring in the pharynx and larynx. Their advantages over radium element needles for this kind of work are ob-

vious, but they also have the following disadvantages which, although they were noted in a previous article,[13] may bear repetition:

1. The walls are only 0.3 mm. thick and allow some of the more irritating rays to pass through.

2. It is difficult to plant such small structures in regular patterns in inaccessible locations.

3. They may slip out of place in the throat and be aspirated, thereby producing a lung abscess.

4. They may produce a necrosis of the cartilage if placed in contact with the epiglottis or other cartilaginous structures of the larynx.

5. They sometimes set up a neuritis producing constant headache about the ear when planted in the upper lateral pharynx.

6. They are expensive and can be obtained only from New York City by those of us who are located in the more remote districts.

In the more accessible lesions, particularly the metastatic nodes in the neck, we have found it advantageous to use Cade's modification of the weak, heavily filtered radium element needles devised by Regaud. The advantages and disadvantages of these needles are described in a previous article.[14]

The results reported by Coutard intrigued the interest of American radiologists immediately, but his plan necessitated the use of an expensive piece of x-ray apparatus for as much as one to four hours daily over periods of three or four weeks on a single patient, and such uneconomical operation could hardly be advocated for a busy clinic. Most of the workers in this country decreased the daily treatment time by reducing the filtration and increasing the voltage and tube current. Although the French method required the use of a filter of 2.0 mm. of zinc, we published data[15] in 1935 indicating that a total dose of 3,600 roentgens (measured in air without backscattering) could completely eradicate a large epidermoid carcinoma, grade III, of the skin of the face when given in twelve equal daily doses with a filter of 0.75 mm. of copper and 1.0 mm. of aluminum. With a kilovoltage of 200, a tube current of 6.0 ma., and a target skin distance of 50 cm., the daily dose could be given in twenty-five minutes. More recently the work of Merritt and Rathbone has convinced us that the skin reactions can be lessened by an increased filtration. By increasing the kilovoltage to 220 and the tube current to 20 ma., it is possible to give a daily dose of 300 roentgens in twenty minutes with a filter of 0.8 mm. of tin, 0.25 mm. of copper, and 1.0 mm. of aluminum, the so-called heavy Thoreaus filter, which is considerably heavier than the one recommended by Coutard himself. A rather limited experience with this technique has led us to adopt it for all work about the throat and neck, but the recent rapid progress in roentgen therapy may cause us to change it before this article appears in print.

In general, our x-ray technique, with the exception of the selection of a filter, follows that recommended by Martin and McNatin.[17] Areas large enough to cover the primary lesion in the throat and its probable immediate paths of extension are mapped out on either side of the neck. They may be circular or square and usually measure from 7.0 cm. to 15.0 cm. in diameter or in width, as the case may be. It is desirable to keep these areas as small as possible in order that the reactions in the normal tissues may be reduced to a minimum. The treatments are given through cones of the size and shape of the mapped-out areas. They are attached to an oil-cooled, shockproof tube holder and may be placed in intimate contact with the skin without danger of electrical shock or even of static discharge.

Usually 300 roentgens measured in air without backscattering are given daily (except Sunday) to alternate sides of the neck. In most instances each skin area receives a total dose varying from 3,000 r. to 3,600 r. When the patient responds poorly, it is often advisable to reduce the daily dose, and in some instances the total dose has been lowered with a favorable outcome. With tumors located on one side of the throat, it has sometimes seemed wise to apply two-thirds of the dose to the affected side and one-third to the other side in an effort to save the function of the salivary glands on the normal side. Coutard states that the cancericidal dose for tumors of the mucous membranes of the throat is about 3,500 r. with backscattering and this should amount to approximately 2,625 r. without backscattering. Treatment should never be stopped until at least this much irradiation as calculated from penetration charts has been delivered to the affected region, and we usually give a minimum of 3,000 r. unless the reaction produced is very severe. In most instances the series is completed during a period of twenty-four to twenty-eight days.

In seven to nine days after the first dose, the patient begins to complain of a sore throat, dryness of the mouth, and difficulty in swallowing. Inspection at or near this time reveals spots of superficial ulceration and the formation of a white membrane on the uvula and anterior pillars. During the next week this reaction appears on the posterior pharyngeal wall, floor of the mouth, insides of the cheeks, epiglottis, base of the tongue, and eventually on the vocal cords and dorsal surface of the tongue. The saliva becomes thick and stringy and the patient finds clearing his throat difficult. The term radioepithelitis is used by Coutard to describe these changes in the mucous membranes.

Near the end of the series of treatments, the irradiated skin takes on a dusky red color. The surface then peels off and large, moist patches which are completely denuded may appear. The use of very heavy filters has in our opinion decreased the degree of denudation. Radioepidermitis is the term applied by Coutard to this skin change.

When the radioepithelitis is at its height, the malignant process melts down rapidly and in the successful cases healing occurs within a week or two, leaving the mucous membranes practically normal in appearance. The skin heals more slowly, but when the dosage has been carefully computed, the end-results are excellent and little external evidence of the treatment remains. The entire process usually requires from six to eight weeks for its consummation. Hayes Martin observes his cases frequently during the healing stages and feels free to insert radon implants into any malignant areas which do not show a satisfactory regression. This procedure is rarely necessary except in the metastatic areas in the neck.

With the onset of the pharyngeal irritation, feeding becomes increasingly difficult. The basis of the diet is milk containing beaten raw eggs, a little orange juice, and malted milk. To this is added cereals, ice cream, creamed soups, puréed vegetables, and any soft foods that the patient will take. Occasionally it is necessary to use a nasal tube for a few days. Swallowing is made somewhat easier by allowing an aspirin tablet to dissolve in the mouth before each meal. A 5 per cent sodium bicarbonate solution is of some value in keeping the mouth and throat clean between meals. Simple soothing applications, such as boric ointment, are all that is needed for the skin reactions. For ten days to two weeks these patients may have a slight temperature elevation. They are quite uncomfortable and usually lose from ten to fifteen pounds. It is essential that they receive vigorous encouragement daily, since they become convinced that the malignant process is progressing and various forms of mental depression are often observed. Fortunately, the radiation effects subside rapidly, and when improvement begins, it progresses with a speed which fully justifies the severity of the treatment.

METASTASES

The metastases of carcinoma of the pharynx and of the intrinsic larynx present entirely different problems, because the laryngeal tumors spread slowly and usually produce symptoms such as hoarseness, cough, dyspnea, pain, or hemoptysis long before extension occurs. For this reason larynx patients are likely to come for treatment early. When metastases do occur, they appear in the adjoining tissues and lymph nodes of the neck, and their appearance taken with the history makes the diagnosis evident. Obstruction of the larynx which often requires the immediate insertion of a tracheotomy tube is the most troublesome complication encountered.

In many instances, pharyngeal malignancies produce so few symptoms that the victims consult a physician only after the manifestations of secondary extensions appear. This is particularly true when the primary growth is located well up in the lateral pharynx. Three such cases have appeared in our clinic with a diagnosis of Hodgkin's disease because of

the large masses of painless glands discovered in the sides of the neck. In the presence of cervical adenopathy, we routinely order a blood examination and a careful examination of the throat before considering the surgical removal of a gland for microscopic study. Carcinoma of the throat occurs with surprising frequency in young individuals and the youthfulness of the patient should never be considered as a point in favor of the diagnosis of lymphoblastoma.

Intracranial nerve involvement as a first symptom of cancer of the pharynx is not at all uncommon. Hansel[18] has recently reported a group of these cases in detail. Every nerve on the affected side except the eighth is sometimes paralyzed. This freedom of the auditory nerve is accounted for by the fact that most of the pressure is exerted by growths of the tumor outside of the cranial cavity and only the eighth nerve fails to pass out through one of the formina in the base of the skull. After pharyngeal carcinoma invades the neighboring tissues, it often causes deafness and tinnitus by blocking the eustachian tube and fixation of the jaw by invasion of the pterygoid and masseter muscles. Upward extension produces invasion of the sphenoids, and at times the sella turcica is partially destroyed. The earliest cranial nerve involvement follows extension of tumor tissue into the sphenoid fissure and an internal strabismus produced by pressure on the sixth nerve, which lies lowest in the fissure, is the first noticeable clinical sign. Pain in the eye, side of the face, and ear from fifth nerve pressure usually appears next and may be followed by blindness from optic atrophy. Other symptoms observed in these cases are facial paralysis, the jugular foramen syndrome, toothache, earache, pain in the tongue, neck and shoulders, exophthalmus, dysphagia, aphonia, hoarseness, dizziness, and contracted visual fields. Every patient with a progressive involvement of intracranial nerves is entitled to a careful examination of the nasopharynx. Good x-ray films of the base of the skull will, at times, show definite erosion of bone about the sella turcica and the foramina for the nerves.

The more embryonic tumors of the upper pharynx spread rapidly to other portions of the body and metastases eventually appear in the mediastinum, lungs, and abdomen. Cappell[19] states that the lymphoepitheliomas usually involve the spine near the termination of the disease.

In primary laryngeal cases, it is sufficient to include the adjoining soft tissues and glands within a 3.5 cm. radius of the center of the larynx in the treated area. However, the pharynx, anterior half of the floor of the skull, and cervical region should be irradiated in dealing with pharyngeal carcinoma, even when no metastases can be demonstrated. Many of the distant recurrences can be dealt with successfully, but it has not been found practical to administer heavy doses to the entire body and therefore no cures are recorded. Definite improvement in paralyzed cranial nerves results from treatment of the base of the skull

if the invasion is recent, and we have seen strabismus, ptosis of the upper lid, partial blindness, and pain in the face and ear clear up completely following irradiation of the side of the skull.

RESULTS OF TREATMENT

In evaluating a new method, the results produced must be carefully compared with those accredited to time-honored surgical procedures. New[20] says: "It is generally recognized that surgery offers little in cases of malignant tumors of the nasopharynx"; and Bloodgood states in *Lewis' Practice of Surgery* that he has been unable to cure cancer of the tonsil with the cautery or with diathermy. Patterson[21] reports 9 successes out of 41 cases of cancer of the tonsil and fauces treated with the endothermy knife. Certainly this degree of success can be obtained only in the very early stages of the disease. When the primary lesion is large and extension has occurred, surgical procedures frequently do little more than add to the patient's discomfort. Reference to Table I, which includes all of our patients treated a year or more ago, shows that all of the cases of pharyngeal carcinoma in our small series obtained a complete regression of the primary tumor and marked improvement appeared in the neighboring extensions even in advanced stages of the disease. Death, when it occurred, resulted from complications or distant metastases. The immediate improvement in the patient's condition was very striking in every instance. Our experience has not extended over a period of five years as yet, but Coutard reported 23 per cent of 46 cases of carcinoma of the tonsil, and 10 per cent of 89 cases of carcinoma of the hypopharynx free of symptoms for a period of five years. Lenz, Coakley, and Stout,[22] using a technique very similar to Coutard's, report 6 cases of cancer of the tonsil and base of the tongue well for periods varying from nine months to two years. Hayes Martin, who uses low filtration to obtain a high x-ray intensity and who inserts radon seeds into stubborn areas, reports 24 per cent of 41 cases of cancer of the tonsil, 35 per cent of 21 cases of cancer of the nasopharynx, and 22 per cent of 9 cases of cancer of the pharynx and soft palate well for periods of one and one-half to three and one-half years. These figures strongly support irradiation as the method of choice in all malignant tumors of the pharynx.

In carcinoma of the intrinsic larynx, a much stronger case can be made out for surgery. New and Waugh[23] report 69 cases out of 135 operated on at the Mayo Clinic free of carcinoma at the end of five years. These authors do not give the number of inoperable cases in their series. However, since the radiologist treats all of the patients applying for treatment, his statistics must be compared with absolute surgical figures if a fair comparison is to be made. Mullin and Darsie[24] found only 54 per cent of 133 cases in their clinic to be operable and we may assume, therefore, that New and Waugh obtained five-year cures in 69 cases out

TABLE I

RÉSUMÉ OF DATA COVERING CASES OF CARCINOMA OF THE THROAT TREATED IN OUR LABORATORY MORE THAN ONE YEAR AGO

Intrinsic Carcinoma of the Larynx

AGE	PRIMARY LESION	PATHOLOGY	METASTASES	DOSAGE	TREATMENT	RESULTS
58	Upper larynx obliterated	Epidermoid carcinoma	None	3,000 r. rt. 3,000 r. lt.	22 days	Free of disease 2 yr. and 1 mo.
50	Posterior rt. vocal cord	Epidermoid carcinoma grade 2	None	3,000 r. rt. 3,000 r. lt.	22 days	Free of disease 1 yr. and 5 mo.
55	Most of left vocal cord	Epidermoid carcinoma	None	2,700 r. lt. 1,200 r. rt.	14 days	Free of disease after 4 yr. and 3 mo.
53	Mass beneath ant. commissure	Epidermoid carcinoma grade 1	None	2,400 r. lt. 1,800 r. rt. 3,000 r. lt. 3,000 r. rt.	24 days 23 days	Free of disease after 4 yr. and 5 mo.
65	Left cord and arytenoids	Epidermoid carcinoma grade 3	None	3,000 r. rt. 3,000 r. lt.	22 days	Free of disease 1 yr. and 8 mo.
64	Rt. arytenoid	Epidermoid carcinoma grade 2	None	3,000 r. rt. 3,000 r. lt.	23 days	Free of disease 1 yr.
67	Rt. epiglottis and rt. larynx	No tissue	Many cervical glands involved	3,900 r. rt.	14 days	Free of disease 1 yr.
56	Upper larynx obliterated	Adenocarcinoma grade 2	None	3,000 r. rt. 3,000 r. lt.	22 days	Died of lung abscess after 2 mo. No cancer found at autopsy
66	Ventricular folds and thyroid cartilage	Epidermoid carcinoma grade 2	Tissues about larynx	3,125 r. rt. 3,000 r. lt.	24 days	Local recurrence after 1 yr.

TABLE I—CONT'D

Carcinoma of Pharynx

AGE	PRIMARY LESION	PATHOLOGY	METASTASES	DOSAGE	TREATMENT	RESULTS
62	Base of tongue and pharynx	Transitional cell grade 3	None	2,700 r. lt. 1,800 r. rt.	17 days	Free of disease 1 yr. and 10 mo.
54	Rt. tonsil and lateral pharynx	Epidermoid carcinoma grade 3	Node in rt. neck	2,700 r. rt. 1,800 r. lt.	16 days	Free of disease 1 yr. and 1 mo.
58	Left upper pharynx	Transitional cell carcinoma	Large mass in left neck	3,900 r. lt. cheek 4,435 mg. hr. in neck	12 days	Free of disease 2 yr. and 6 mo.
64	Right pharynx	No tissue	Large node in neck	3,100 r. rt. neck 1,750 r. lt. neck	21 days	Free of disease 1 yr.
70	Pharynx and nose	Transitional cell grade 3	Neck Mediastinum Abdomen	2,950 r. lt. 2,950 r. rt.	24 days	Died of metastases after 5 mo. Throat clear of disease
45	Rt. pharynx and epiglottis	Epidermoid carcinoma grade 3	Many glands right neck	3,900 r. rt. neck	15 days	Died of metastases after 9 mo. Throat clear of disease
34	Rt. pharynx	Transitional cell grade 4	Mass in rt. neck	3,900 r. rt. neck	14 days	Throat clear. Small node in neck after 1 yr. 6 mo.
50	Rt. pharynx	Lymphoepithelioma	Neck, lung Mediastinum Abdomen	2,300 r. rt. neck 1,500 r. ant. chest 1,500 r. post. chest	30 days	Died of metastases after 4 mo. with throat, chest, and neck clear

of a total of approximately 250 patients. If we accept this theoretical figure, they obtained 27.6 per cent absolute cures in their series. Coutard reports 21 per cent of five-year cures in his series of 60 irradiated cases and these figures suggest that ultimate results are similar for the two methods. Lenz, Coakley, and Stout report 5 cases out of 11 free of disease for periods varying from nine months to two years. And Martin and McNatin report 3 of 4 cases of carcinoma of the intrinsic larynx clear of disease for periods varying from nine months to two and one-half years. In our own clinic, 6 cases out of 9 have remained free of disease for periods varying from one year to four years and three months.

Assuming that the chance of cure is about the same with the two methods, it would seem at first glance that there is little choice between them. However, New and Waugh found it necessary to do a laryngectomy in 44 per cent of their cases who were thereby deprived of any possible future use of the vocal cords and who were also condemned to the use of tracheotomy tubes for the remainder of their lives. Although a thyrotomy was done in the others, they could not be assured of a useful voice. It is true that rather complicated mechanical devices have been used successfully for speaking, but normal use of the trachea for speaking and breathing is highly desirable. Although tracheotomy tubes were used temporarily in three of our worst cases, it was found necessary to leave the tube in place permanently in only one case. All of our other successful cases obtained a usable voice, although many of them could only speak in a whisper when the treatment was started. When all of these facts are taken into consideration, it is our feeling that irradiation should be the method of choice even in the early cases. If regression is not complete, operative procedures can always be carried out at a later date. New and Waugh observed that they obtained no operative cures in cases having grade IV epidermoid carcinomas and for this reason surgeons who still favor the operative methods should treat only the tumors having a low histologic grading. We feel very definitely that inoperable patients as well as those on the borderline should receive irradiation because they almost always obtain some degree of improvement and surgical procedures frequently make them very much worse.

The following case histories have been selected because they show that malignant tumors of the pharynx and larynx can be eradicated with the external use of x-rays alone and they also indicate that the pathologic histology makes little difference in the ultimate response of the primary growth:

CASE 1.—A white woman, fifty-four years of age, began to have attacks of discomfort in the right side of the throat ten months before admission. Her physician told her that she was suffering from a recurrent tonsillitis and minimized the importance of the condition. Seven months later a gland appeared beneath the angle of the right jaw and swallowing became painful. One week before admission another physician discovered a tumor in her throat.

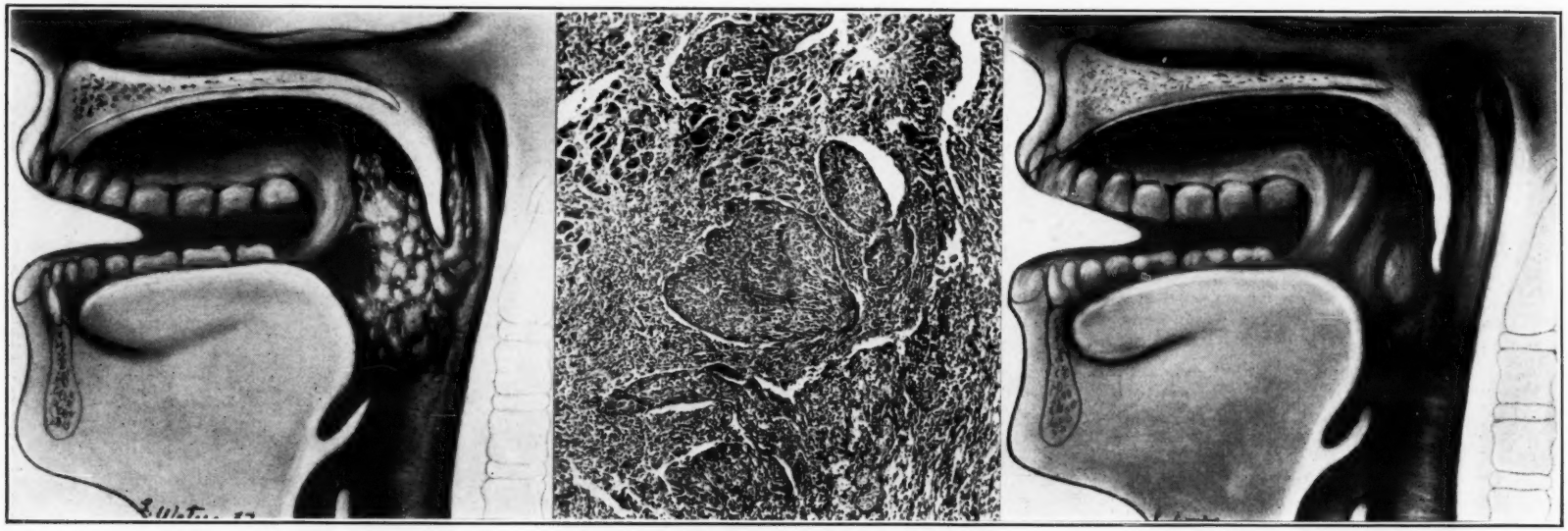

Fig. 1.—An epidermoid carcinoma of the right tonsillar region in Case 1 before and one year after the use of modified Coutard x-ray therapy over the sides of neck. The patient is now entirely symptom free.

At admission a flat tumor with a friable surface was seen to extend from the right anterior pillar backward across the tonsillar area onto the pharyngeal wall. This growth measured one and one-half inches in diameter. The histologic diagnosis was epidermoid carcinoma, grade III. A single gland beneath the angle of the right jaw measured one inch in diameter.

During a period of sixteen days, 2,700 r. (measured in air without backscattering) were administered on the right side of the neck to a square area measuring 10 cm. on a side, and 1,800 r. were given through a circular port measuring 7 cm. in diameter on the left side. Three hundred roentgens were given each day with 220 kv., a target skin distance of 50 cm., and a filter of 2.0 mm. of copper and 1.0 mm. of aluminum. The current through the tube was 20 ma.

By the sixteenth day she had developed such a severe epithelitis that it seemed wise to discontinue treatment. She returned on the twenty-sixth day after the series was completed, at which time the tumor in the throat had disappeared leaving the mucous membrane smooth and normal in appearance. The gland was reduced to less than half its former size. After thirty-three more days had elapsed, no gland could be palpated, but she complained of a dry throat and a tenacious sputum. She has remained entirely well with no evidence of a recurrence for one year and three months.

CASE 2.—A white woman, sixty-five years of age, came to the hospital complaining of soreness in the left side of her throat of about a month's duration. Four years previously some sort of gland of unknown origin was removed from the left side of the neck. Seven months before admission a large swelling appeared in the left side of the neck, but it gradually subsided. The treatment consisted solely of cold applications and rest. She became alarmed recently when she discovered a tumor in the region of the left tonsil.

Examination revealed an irregular tumor mass with a friable surface measuring one and one-fourth inches in diameter replacing the left tonsil. Nothing abnormal was felt in the neck except a small node well down in its midportion on the left side. A piece of the tumor was removed and diagnosed as lymphosarcoma by Dr. George Caldwell. Doses of 2,700 r. on the left side and 1,500 r. on the right side were delivered to the pharynx through square ports measuring 10.0 cm. on a side. The daily dose was 300 r.; the kilovoltage, 220; the filtration, 0.8 mm. of tin, 0.25 mm. of copper, and 1.0 mm. of aluminum; the distance 50 cm.; and the current 20.0 ma. On the fifth day of treatment the tumor had completely disappeared. An examination done after six weeks revealed no evidence of malignancy in the throat, neck, or chest. Although she had a rather severe reaction, both inside the pharynx and over the skin of the left side of the neck, it subsided rapidly, leaving no sequelae except some dryness of the mouth and a disturbed sense of taste.

CASE 3.—A colored boy, nineteen years old, was brought to the hospital because of hemorrhages from his nose during a period of seven weeks. For about six weeks, glands had been growing rapidly in both sides of his neck. For one week he had found it very difficult to open his mouth or to chew because of pain in the cheeks and limited motion of the lower jaw.

At admission he looked quite ill and was slender and poorly nourished. Large masses of glands were palpable on both sides of the neck. Dr. Lyle Sellars reported a large mass of malignant tissue filling the upper portion of the nasopharynx and extending into the nasal passage. He removed a specimen which was diagnosed as transitional cell carcinoma, grade III.

Areas measuring 15.0 cm. on a side were laid out to include the cheek, pharynx, anterior half of the base of the skull, and neck on each side of the head. Each area received 2,950 r. given during a period of twenty-four days. The treatment factors

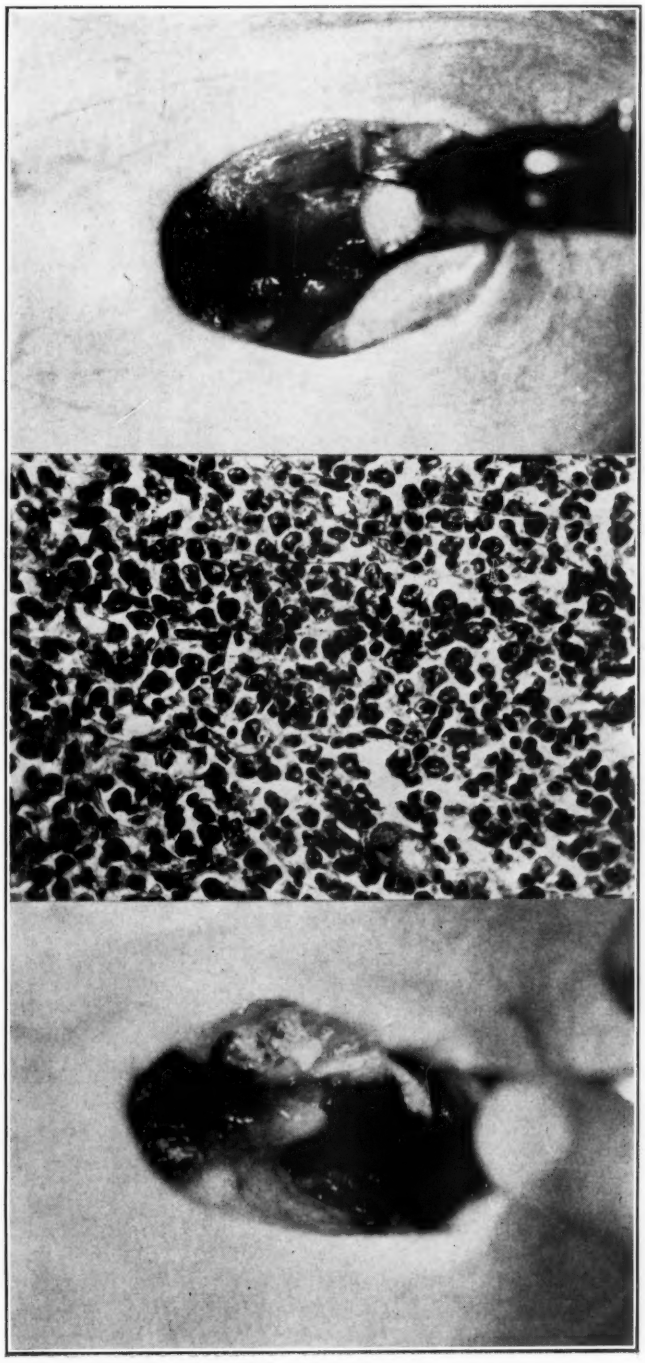

Fig. 2.—Large lymphosarcoma of the left tonsil before and five days after beginning a modified series of Coutard x-ray treatments over the sides of the neck in Case 2. No evidence of the disease is made out at the end of six weeks.

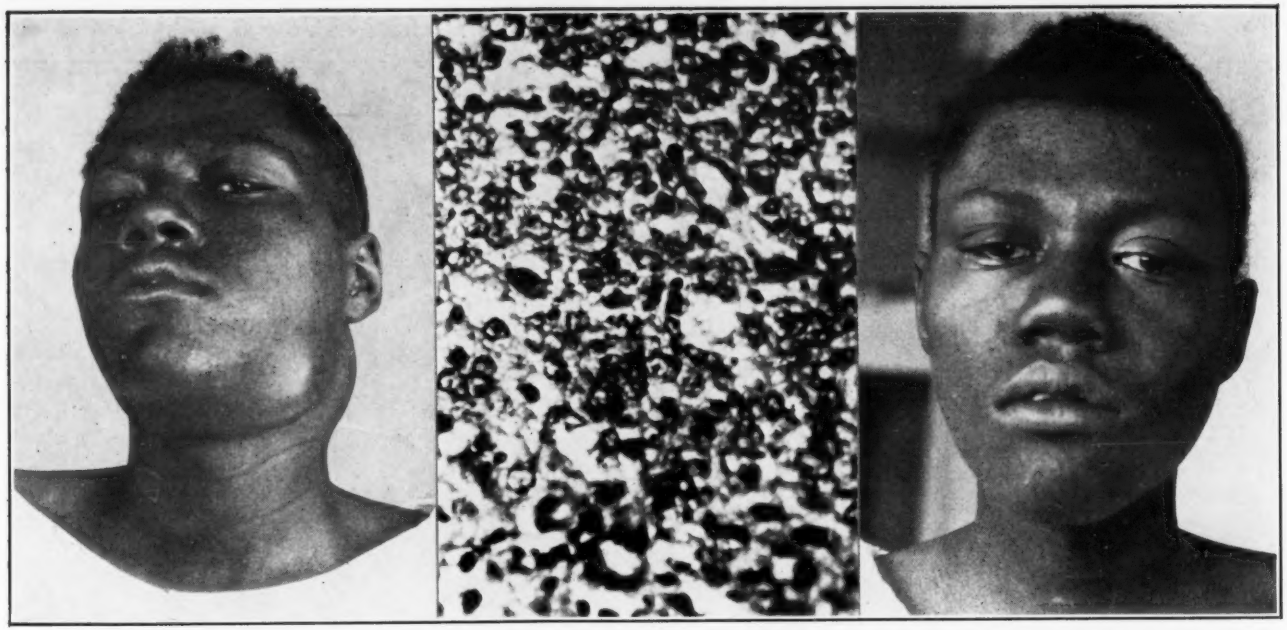

Fig. 3.—Large glands in the neck secondary to a transitional cell carcinoma of the nasopharynx before and after the use of a modified Coutard series of x-ray treatments over the lateral cervical regions in Case 3. A diagnosis of Hodgkin's disease was made by the admitting physician.

were: 220 kv., 20.0 ma., a target skin distance of 50.0 cm., and a filter of 0.8 mm. of tin, 0.25 mm. of copper, and 1.0 mm. of aluminum. By the time the series was completed the neck had a normal appearance and the nasopharynx was almost clear of disease.

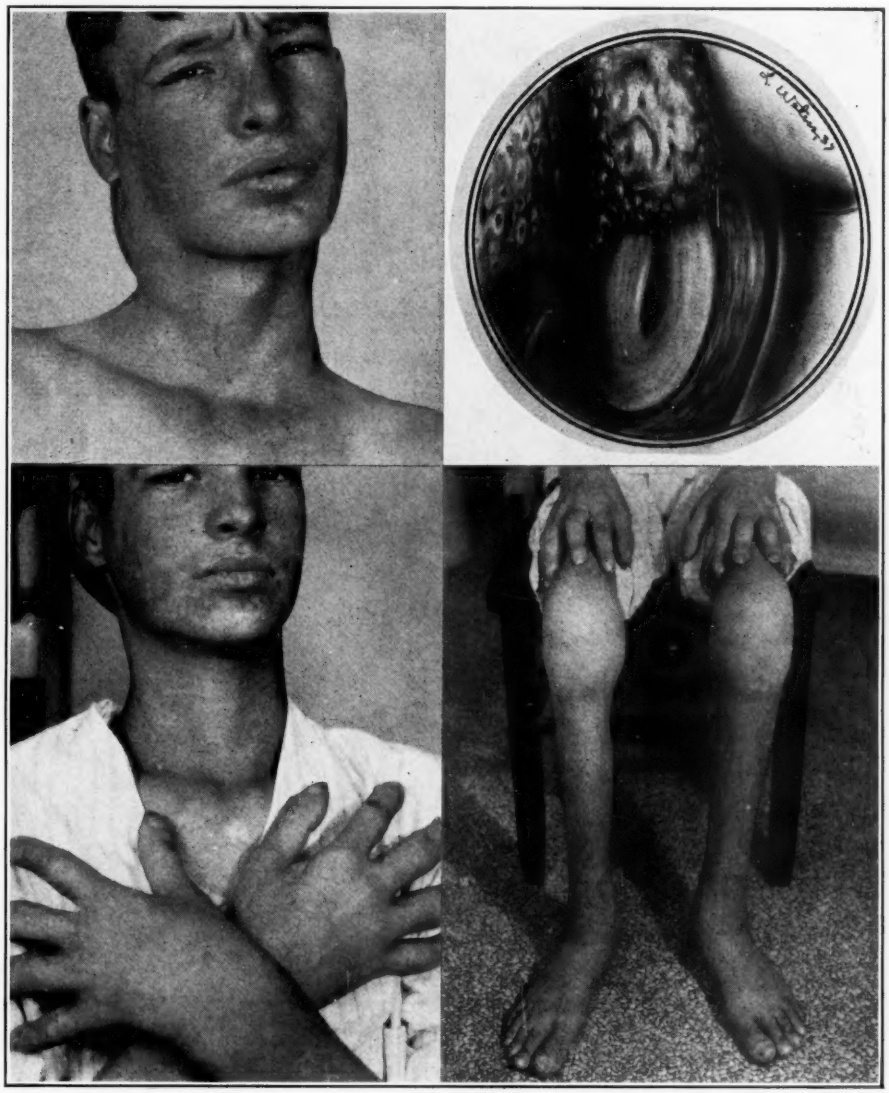

Fig. 4.—Transitional cell carcinoma arising in the right fossa of Rosenmüller and producing cervical adenopathy. The drawing represents the primary lesion as it appeared in the pharyngeal mirror. (This drawing is inverted.) The lower photographs show the pulmonary osteoarthropathy observed in the hands, knees, lower legs, and feet when he returned 6 months after x-ray treatment with no demonstrable evidence of malignancy present.

He returned five months later because of loss of weight, pain in the lower back, and loss of the control of his legs and bladder. A film of the chest revealed mediastinal nodes. His neck and throat still had a normal appearance. His hands and feet showed a generalized soft swelling and the fingers and toes showed a tendency toward clubbing. The knees were also swollen.

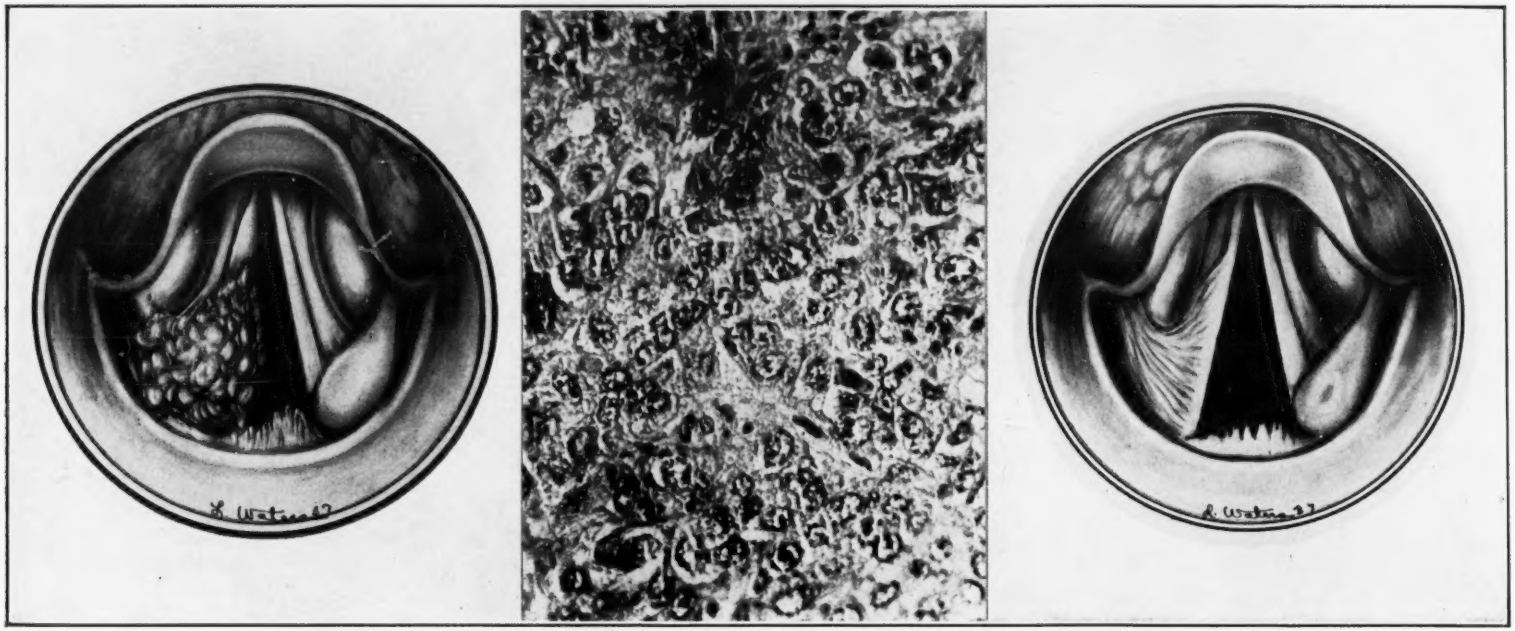

Fig. 5.—Drawings made from sketches of the laryngeal mirror appearances of an epidermoid carcinoma of the left vocal cord before and one year after treatment with a modified Coutard series of x-ray treatments in Case 5. The sketches were made by Dr. Lyle Sellars. The high power photomicrograph indicates the malignant nature of the tumor cells.

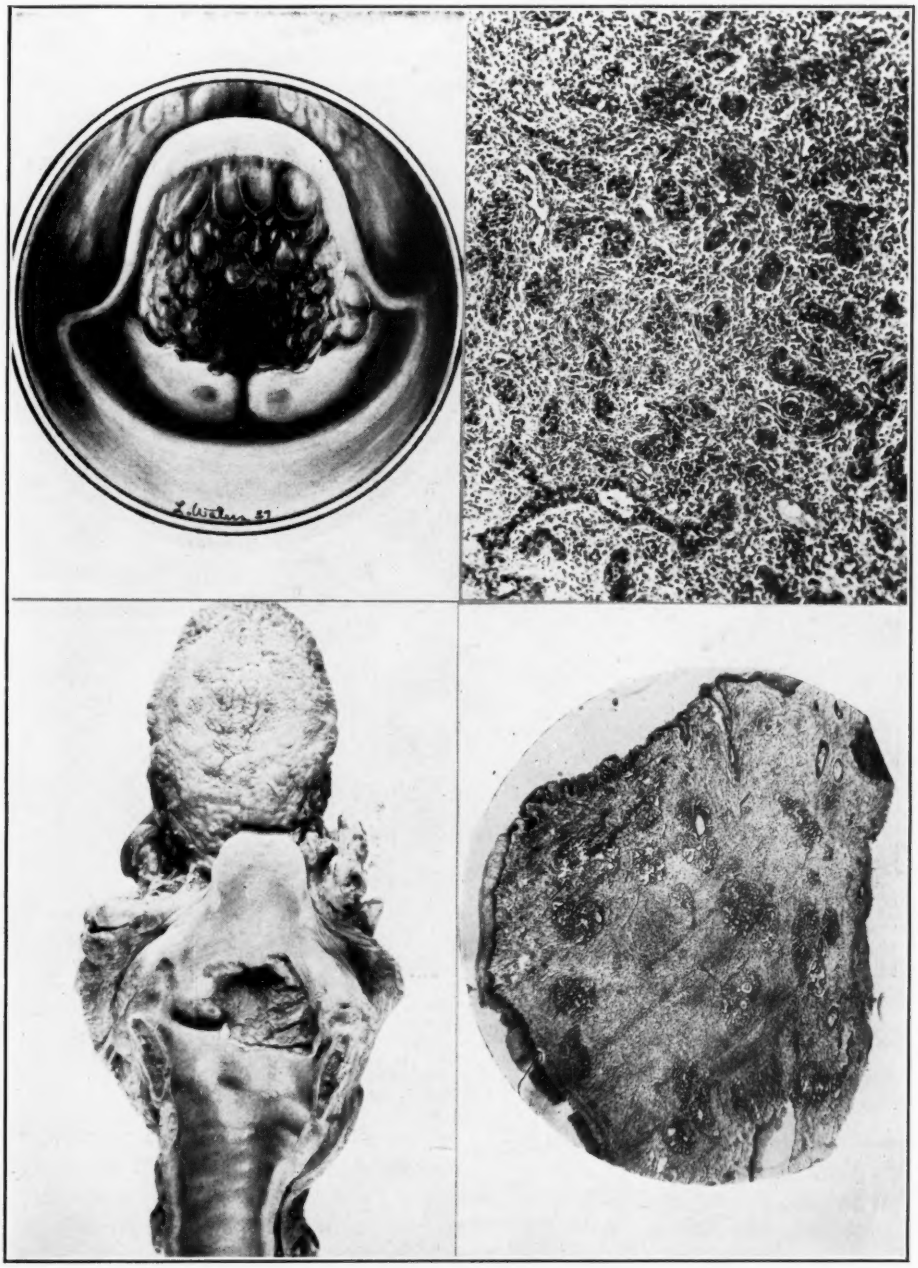

Fig. 6.—The drawing represents the laryngeal mirror appearance of a large adenocarcinoma of the larynx in Case 6. It was producing almost complete obstruction before x-ray treatment was administered. The upper photomicrograph is made from a biopsy specimen from this tumor. The photograph shows a shallow ulcer in the larynx as it appeared at autopsy 6 weeks after treatment, following death from a complicating lung abscess. The lower photomicrograph represents one of numerous sections showing no malignancy, taken from the edges of the residual ulcer. These illustrations prove that even a large carcinoma of the larynx may be eradicated with x-ray therapy.

Single erythema doses given over the entire spine produced some temporary relief, but he returned home where he died about two months later.

CASE 4.—A white boy, fifteen years of age, came to Baylor Hospital because of large painful glands in his neck and a rapid loss of twenty-five pounds in weight. His trouble started seven months previous to admission with a tinnitus on the right side. Glands soon appeared on the right side of the neck and grew rapidly so that they produced stiffness and soreness. After four months similar glands appeared on the left side of the neck.

Examination showed the patient to be a slender, poorly nourished boy who was very uncomfortable because of a hard tumor mass about 3 inches in diameter felt below the angle of the right jaw. Smaller nodes were felt on the left side in the same region. An examination of the throat done by Dr. Lyle Sellars revealed a tumor in the fossa of Rosenmüller on the right side just above the eustachian tube orifice. One of the glands was removed and the histologic diagnosis made by Dr. George Cald-

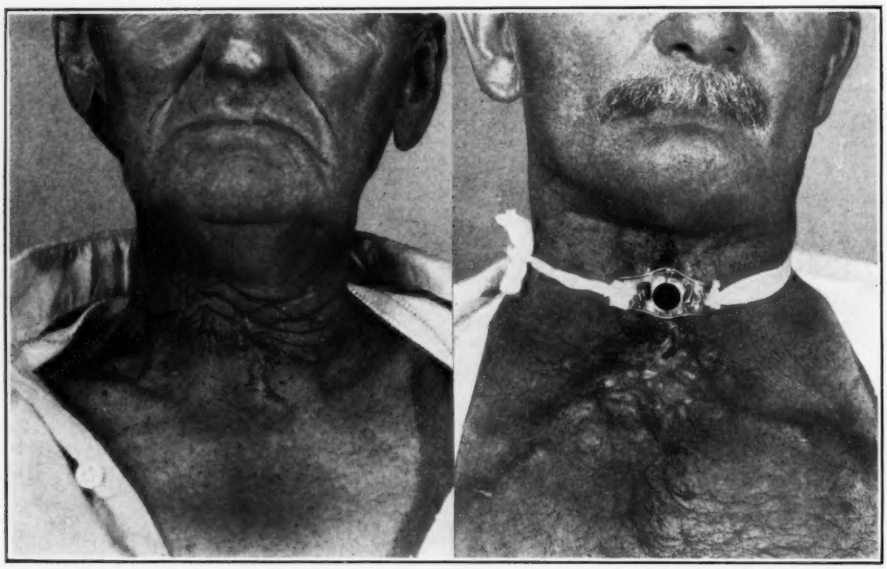

Fig. 7.—The photograph on the left represents the neck of a patient with an advanced, inoperable carcinoma of the larynx as it appeared one year after a series of modified Coutard x-ray treatments. There is still some carcinoma present but no tracheotomy tube is necessary. The other photograph represents the extensive metastases in the neck 2 months after a laryngectomy in an inoperable case. It seems evident that irradiation offers the best palliation in such cases.

well was transitional cell carcinoma, grade II. Doses of 3,300 r. to the right side and 2,700 r. to the left side of the neck were given through square portals measuring 15 cm. on a side. The factors used were 220 kv., 20 ma., a target skin distance of 50 cm., and a filter of 0.8 mm. of tin, 0.25 mm. of copper, and 1.0 mm. of aluminum. This treatment was given during a period of twenty-six days, and at the end of the series all evidence of the disease had disappeared both in the throat and in the neck.

He returned to the hospital after six months complaining of pain and swelling in his hands, feet, and knees. The fingers and the toes showed definite clubbing, but no evidence of pulmonary or cardiac disease could be made out. Roentgen ray examinations of the extremities showed periosteal changes in all of the bones examined of the type seen with pulmonary osteoarthropathy. Since similar clinical findings occurred in Case 3, carcinoma of the pharynx may be one of the underlying causes of

pulmonary osteoarthropathy. There was still no evidence of malignancy made out in the throat, neck, or chest at this visit.

CASE 5.—A white man, sixty-five years of age, came to the hospital because of a complete loss of his voice and some pain in the region of the right ear. He began to be quite hoarse four months before admission and the condition slowly grew worse until he could only speak in a whisper. Dr. McNelly made a diagnosis of carcinoma of the left vocal cord by inspection and Dr. Lyle Sellars removed a piece of tissue from this region. The biopsy report was epidermoid carcinoma, grade III. No external evidence of malignancy was palpable in the neck. Three hundred roentgens were given daily to alternate sides of the larynx, using circular ports measuring 7 cm. in diameter until each side received 3,000 r. The treatment factors were 220 kv., 20 ma., a filter of 2.0 mm. of copper and 1.0 mm. of aluminum, and a target skin distance of 50 cm.

When he returned six weeks after the series was finished, he had a fairly good, rather husky speaking voice and the vocal cords had a normal appearance except for the presence of a little edema.

One year and one month have elapsed since he was treated and Dr. Sellars states that the cords now have a normal appearance. He has a good speaking voice which is slightly husky, and he looks and feels quite well.

CASE 6.—A white man, fifty-six years of age, came to the hospital because of extreme dyspnea, loss of weight, and difficulty in swallowing. He had complained of cough and hoarseness for seven years, and six months before admission a piece of tissue diagnosed as carcinoma was removed from the intrinsic larynx in another institution by Dr. Lyle Sellars.

He stated that he had received thirty-four x-ray treatments over the neck in another laboratory, but his condition seemed to grow steadily worse so that breathing became very laborious and he developed a marked dysphagia causing him to lose a total of sixty pounds.

At admission Dr. Sellars reported the intrinsic larynx completely filled with carcinoma, except for a slitlike opening in its central portion. No glands were felt in the neck. A piece of tissue removed from the tumor was diagnosed by Dr. George Caldwell as adenocarcinoma, grade II.

Doses of 300 r. were given daily to alternate sides of the neck through round ports measuring 7 cm. in diameter, until a total of 3,000 r. was administered to each side using 220 kv., a filter of 0.8 mm. of tin, 0.25 mm. of copper, and 1.0 mm. of aluminum, and a 50 cm. target skin distance.

He had a cough and some temperature elevation when the treatment was finished, but his cough, which was now productive, continued. Roentgenograms of his chest showed a large abscess in the left upper lobe. His general condition did not improve and he died six weeks after the completion of the series of treatments.

A postmortem examination showed a depressed area about three-fourths of an inch in diameter in the inner wall of the larynx at the site of origin of the carcinoma as well as a large abscess in the left upper lung. Sections taken from the edges of the involved region in the larynx showed no evidence of carcinoma, and it seems fair to assume that this patient was free of malignant disease at the time of his death.

SUMMARY

Evidence is presented to show that irradiation therapy is the method of choice in all malignant tumors of the pharynx and larynx. Certainly it should replace surgery in all borderline and inoperable cases.

REFERENCES

1. Coutard, H.: Roentgen Therapy of Epitheliomas of the Tonsillar Region, Hypopharynx and Larynx From 1920 to 1926, Am. J. Roentgenol. **18**: 313-331, 1932.
2. Ewing, J.: Lymphoepithelioma, Am. J. Path. **5**: 99-107, 1929.
3. Quick, D., and Cutler, M.: Transitional Cell Epidermoid Carcinoma, a Radiosensitive Type of Intraoral Tumor, Surg., Gynec. & Obst. **40**: 320, 1927.
4. Martin, H. E., and Pflueger, O. H.: The Comparative Radiosensitiveness of Pharyngeal Tumors, Radiology **17**: 425, 1931.
5. Caldwell, George T.: Reticuloendothelial System and Its Relation to Neoplastic States, South. M. J. **27**: 205, 1934.
6. Clerf, L. H., and Crawford, B. L.: Carcinoma of the Larynx, Arch. Otolaryng. **16**: 676-689, 1932.
7. Cade, S.: Radiation Treatment of Cancer of the Mouth and Pharynx, Lancet **225**: 4-11, 1933.
8. Cutler, M.: Radium Dosage and Technique in Carcinoma of the Tonsil, Pharynx and Larynx, Am. J. Roentgenol. **33**: 690-693, 1935.
9. Garland, L. H.: Treatment of Carcinoma of the Pharynx and Larynx, Radiology **24**: 261-275, 1935.
10. Martin, H.: Fractional or Divided Dose Method of External Irradiation in the Treatment of Cancer of the Pharynx, Tonsil, Larynx and Paranasal Sinuses, Acta radiol. **16**: 1-24, 1934.
11. Quick, D.: Radium Implantations in Certain Growths of the Hypopharynx, Radiology **21**: 114, 1933.
12. Failla, G.: The Development of Filtered Radon Implants, Am. J. Roentgenol. **16**: 507-525, 1926.
13. Martin, Chas. L.: Carcinoma of the Upper Pharynx, Am. J. Surg. **30**: 36-45, 1935.
14. Martin, Chas. L.: Small Radium Needles Versus Radon Implants, Am. J. Roentgenol. **27**: 240-248, 1932.
15. Martin, James M., and Martin, Chas. L.: Modified Coutard Roentgen Therapy, **J. A. M. A. 104**: 605-608, 1935.
16. Merritt, E. A., and Rathbone, R. R.: The Roentgen Treatment of Malignancy Using Filtration Equivalent to 5 mm. of Copper, Am. J. Roentgenol. **35**: 334-343, 1936.
17. Martin, Hayes E., and McNatin, Robt. F.: The Treatment of Cancer of the Pharynx, Tonsil and Extrinsic Larynx by Divided Doses of External Radiation, Am. J. Roentgenol. **32**: 717-729, 1935.
18. Hansel, Frank K.: Malignant Tumors of the Nasopharynx With Involvement of the Nervous System, Ann. Otol., Rhin. & Laryng. **41**: 74-93, March, 1932.
19. Cappell, D. F.: On Lymphoepithelioma of the Nasopharynx and Tonsils, J. Path. & Bact. **39**: 49-64, 1934.
20. New, G. B.: Treatment of Malignant Tumors of the Pharynx and Nasopharynx, Surg., Gynec. & Obst. **40**: 177-182, 1925.
21. Patterson, N.: The Use of the Diathermy Knife in Malignant Disease of the Mouth, Nose and Throat, Lancet **227**: 633, 1934.
22. Lenz, M., Coakley, C. S., and Stout, A. P.: Roentgen Therapy of Epitheliomas of the Pharynx and Larynx, Am. J. Roentgenol **32**: 500-507, 1934.
23. New, G., and Waugh, J. M.: The Curability of Carcinoma of the Larynx, Surg., Gynec. & Obst. **58**: 841-844, 1934.
24. Mullin, Wm., and Darsie, L. L.: Carcinoma of the Larynx. A Study of 133 Cases, S. Clin. North America **15**: 851-858, 1935.

A STUDY OF THE LIPEMIA CURVE FOLLOWING SURGICAL OPERATIONS UNDER ETHER ANESTHESIA

WILLIAM P. MONTANUS, M.D., AZEL AMES, M.D., AND
LOUIS G. HERRMANN, M.D., CINCINNATI, OHIO

(From the Department of Surgery, College of Medicine of the University of Cincinnati, and the Kuhn Memorial Laboratory of the Cincinnati General Hospital)

ON THE basis of their nontraumatic conception of the etiology of certain cases of fat embolism, Lehman and Moore,[1] in 1927, advanced the theory that certain ether deaths after prolonged anesthesia may be due to fat embolism and that a proportion of postoperative pulmonary complications might likewise be initiated by fat emboli in the lungs.[2] The results of their experimental work quite justified these speculations. They had actually produced pulmonary fat embolism by ether anesthesia in fat-fed dogs and demonstrated, by repeated chylomicron counts[2, 3, 4] during the course of anesthesia, a gradual diminution in the number of microscopic droplets in the plasma lipoid emulsion. To explain these observations, the suggestion has been offered that ether may break the emulsion and dissolve free fat which then precipitates in alveolar capillaries as the ether vapor tension is reduced. This theory implies an actual reduction in the lipoid content of the blood after ether anesthesia, which is contrary to the observations of all investigators in this field, who have employed quantitative chemical methods. An analysis of the work of these investigators, however, shows that in no case has the lipemia curve been followed after anesthesia into the period of recovery.

It is the purpose of this study to determine whether, in a small series of typical surgical operations under ether anesthesia, any characteristic lipemia curve or consistent lipoid shift can be detected during the course of anesthesia or in the first twenty-four hours after operation.

REVIEW OF THE LITERATURE

A. *Studies in Man.*—Only two investigators have reported quantitative chemical determinations of the blood lipoids before and after ether anesthesia in human subjects.

1. Potter[5] in "Changes in the Blood in Anesthesia," published in 1925, included determinations of the total fat, cholesterol, and total acid-soluble phosphorus upon oxalated whole blood of five relatively normal gynecological patients, taken one hour before and immediately

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after drop ether anesthesia induced by chloroform and lasting from fifteen to sixty minutes. There was identical fasting, catharsis, and preliminary medication (morphine gr. ¼, atropine sulphate gr. $\frac{1}{150}$) in all cases. The phosphorus determinations were made by Zucker and Gutman's modification of Fitter's gravimetric method, but no mention was made of the methods employed for determining total fat or cholesterol. The total lipoid content increased in two cases (684 to 786 mg. per cent, 943 to 955 mg. per cent), decreased in two cases (933 to 798 mg. per cent, 1228 to 1219 mg. per cent), and remained practically unchanged in one case (918 to 920 mg. per cent). The cholesterol, determined in only three cases, showed very little change (225 to 227 mg. per cent, 216 to 210 mg. per cent, 239 to 221 mg. per cent). The total acid-soluble phosphorus increased slightly in four of the five cases (40.3 to 44.7 mg. per cent, 32.3 to 35.8 mg. per cent, 48.1 to 51.0 mg. per cent, 39.0 to 44.0 mg. per cent). In one case there was a decrease from 40.1 to 31.4 mg. per cent.

2. Mahler, in 1926, studying "Blood Cholesterol During Ether Anesthesia,"[6] made determinations of total cholesterol (free cholesterol and cholesterin esters) by Lieboff's technique on the oxalated whole blood of two series (eighteen and thirty-seven cases) of unselected adults subjected to prolonged drop ether anesthesia induced by nitrous oxide. All patients were prepared by fasting for fourteen hours and by a hypodermic injection of morphia gr. ¼ given thirty to sixty minutes before operation. Control determinations of cholesterol were made in every case immediately prior to induction of the anesthesia. No determinations of total fat or lecithin were made. The fasting control specimen in the combined series averaged 176.6 mg. per cent while the average of determinations made near the end of anesthesia (maximum in each case) was 209.6 per cent. There was a rise in every case and the average increase in total cholesterol content of the blood during ether anesthesia was 33.0 mg. per cent.

B. *Studies Upon Experimental Animals.*—Seven investigators have reported determinations of various blood lipoid constituents before and after ether anesthesia in dogs and rabbits.

1. In 1908, Reicher[7] paved the way for others by indicating that the blood fat content of etherized dogs was higher than that of unanesthetized control animals. Using gravimetric methods, he determined the fat, lecithin, cholesterol, and free fatty acids in an alcohol-ether extract of 100 c.c. of blood taken from each of two dogs subjected to ether anesthesia after preliminary fasting. Unfortunately, he did not make determinations before anesthesia on the same dogs, but comparison of the averaged determinations on the etherized pair with the average values obtained from a pair of control animals showed that the total blood fat content was 248 per cent higher in the anesthetized

dogs. This difference was shown throughout the lipoid partition with neutral fat 0.618 gm., or 266 per cent, higher; and lecithin 0.411 gm., or 313 per cent; cholesterol 0.167 gm., or 128 per cent; and free fatty acids 0.250 gm., or 284 per cent, higher than in the controls.

2. In 1914, Bloor[8] demonstrated a consistent but more modest rise (40 to 100 per cent) in the total blood fat content (fatty acids plus cholesterol, determined by the nephelometric method) of four dogs which had been subjected to ether anesthesia for from one to three hours, after variable preliminary starvation. While the lipemia curves were by no means identical, there was a decided rise, sharp at first, then gradual in three out of four, with an actual increase ranging from 0.12 per cent to 0.55 per cent and averaging 0.27 per cent total fat in the blood. Bloor suggested that this rise might be due to solvent action of the blood-ether mixture on fat depots in the tissues.

3. In 1916, Mann,[9] using Bloor's nephelometric method, determined the total cholesterol content of the blood in one 17.6 kg. bitch before and during prolonged ether anesthesia. The curve rose sharply from 0.266 per cent to 0.312 per cent during the excitement stage, and after one and one-half hours had dropped to 0.180 per cent. The peak, 0.358 per cent, was reached after seven hours of anesthesia.

4. In 1919, Ducceschi[10] subjected dogs to ether anesthesia for periods of sixty to ninety minutes daily and found a marked rise in blood cholesterol.

5. In 1931, Tetsu Kinoshita,[11] studying the effect of inhalation ether anesthesia upon the total fatty acids, cholesterol, and phosphatides of the blood of the rabbit, found that the fatty acids and cholesterol were increased, reaching a maximum three hours after narcosis, with a return to normal values after twenty-four hours. Phosphatides were decreased.

6. In 1933, Ghose[12] reported determinations (by Bloor's method of extraction and the Liebermann-Burchard reaction) of the cholesterol content of whole blood of 7 albino rabbits, before, during, and after drop ether anesthesia maintained for one hour and then forced to fatal termination. The values increased from an average normal level of 75.4 mg. per cent to an average of 92.5 mg. per cent during anesthesia and rose to a peak of 114.7 mg. per cent immediately after death.

7. Hospers,[13] also in 1933, determined total cholesterol (by Sackett's modification of Bloor's methods) in the whole blood of six rabbits and five dogs at thirty-minute intervals during open surgical ether anesthesia. In rabbits, the peak of cholesteremia was reached approximately one hour after induction of the anesthesia and varied from 38 mg. per cent to 100 mg. per cent above the normal level (60 to 90 mg. per cent), to which the curve gradually returned after four hours of anesthesia. In dogs, the hypercholesteremia was not as high and

fluctuated more. The peak of increase varied between 18 mg. per cent and 42 mg. per cent, and the curve approached normal (130 to 150 mg. per cent) after five hours of anesthesia.

It will be seen that all observers have reported an increase in the various blood lipoid constituents during ether anesthesia except Potter, who was the only investigator to make determinations of total fat changes in man. While her series is small, the extreme variability of changes in total fat which she observed is more consistent with our findings than those of any of the other investigators.

OUTLINE OF THE STUDY

It was obviously impossible to control the innumerable factors influencing lipemia in a heterogeneous group of diseased individuals subjected to various operative procedures and anesthetics. Prolonged preliminary starvation was out of the question and, furthermore, would have defeated the purpose of the study. Except in a few cases, there was no opportunity for determining the normal variation and probable error of the daily fasting blood lipoid level in each individual before operation. It was, therefore, decided to accept as a standard the values for the early morning fasting total lipoid content of the serum which we[14] had previously determined by using Rückert's lipokrit method[15] in a series of twenty-four normal adults on a regular hospital diet. This group was composed of twelve males and twelve females, ranging in age from eighteen to eighty-three years, with an average age of 34.7 years. None varied more than 10 per cent from the normal weight, for their height and age. Their fasting lipemia levels ranged from 427 ml. per cent to 703 ml. per cent, with a mean value of 550 ml. per cent. With these values as a standard fasting lipemia range, from which deviation could be measured, we proposed to use the same lipokrit method and plot the postoperative lipemia curves in twenty-four routine surgical patients.

The patients were not selected in any way except by the factor of their willingness to submit to repeated venipuncture and by our desire to obtain an equal number of patients given ether anesthesia and patients in whom some other anesthetic was to be used. One case was chosen at random from the operating schedule each day, without consideration of the nature of the operative procedure or the disease for which operation was to be performed. All patients fasted approximately fourteen hours before operation and received practically identical preliminary medication (morphia gr. $\frac{1}{6}$ or $\frac{1}{4}$, and atropine gr. $\frac{1}{150}$). A series of six specimens of blood were taken from each patient at significant intervals, before, during, and after operation, covering the twenty-four-hour period. The fasting or anteoperative specimen was drawn in the operating room just before induction of the anes-

thesia. The second specimen was taken as soon as surgical anesthesia had been obtained. The third was withdrawn at the end of operation while the patient was still on the operating table. The postoperative specimens were obtained at four-, eight-, and twenty-four-hour intervals. None of the patients were given food until after the twenty-

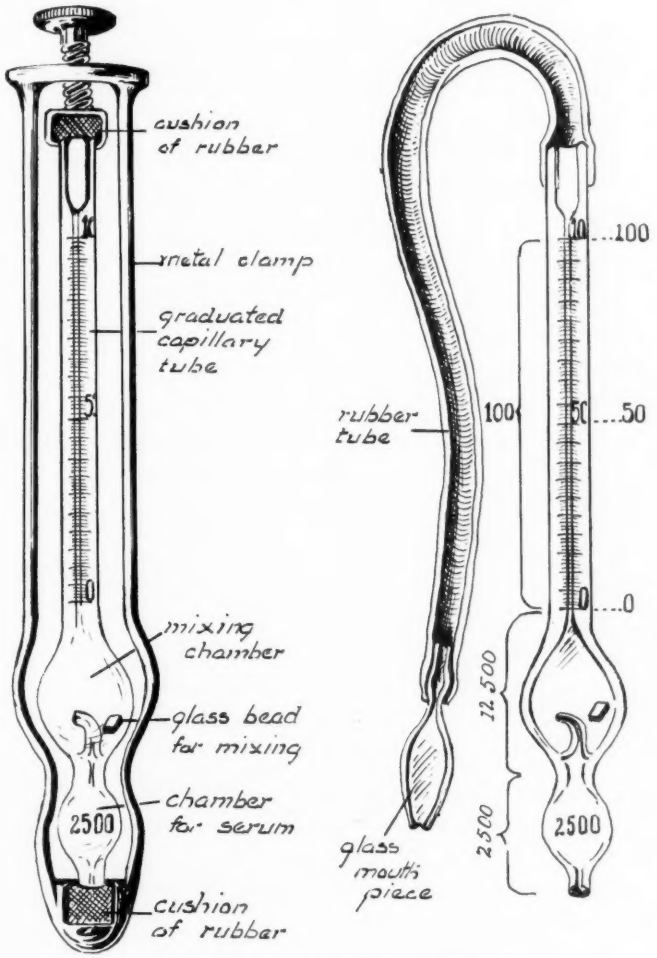

Fig. 1.—Rüchert's lipokrit pipette and clamp.

four-hour specimen had been taken, though a few received physiologic saline solution by hypodermoclysis or 10 per cent dextrose solution intravenously.

The total lipoid content of the serum of each specimen was determined in duplicate by the lipokrit method.[14] This is a simple volumetric micromethod based on the principle of the Babcock test for milk fat. The lipoids are liberated from the serum in two fractions by the action of sulphuric acid, amyl alcohol, and centrifugation. The neutral fats, free fatty acids, and cholesterol break from emulsion

almost immediately, while the fatty acids of conjugated lipides such as lecithin agglomerate after twelve hours of hydrolysis. This process is accomplished by means of Rückert's lipokrit pipette equipped with bulbs, in which the serum sample and reagents are automatically mixed in the proper proportions, and a calibrated stem in which the volume of coalesced lipoid material may be measured after centrifugation (Fig. 1). The usual precautions were taken to render fat-free all needles, syringes, test tubes, and pipettes. After the blood had clotted, the serum was separated by slow centrifugation at 1,000 revolutions per minute and transferred to another tube by means of a capillary pipette. The lipokrit pipettes were then filled with serum and reagent mixture, shaken mechanically for five minutes, and centrifuged for ten minutes at 3,000 revolutions per minute. Whenever there was a discrepancy between the final duplicate values, the average of the pair was recorded.

In order to detect gross shifting of plasma fluid which might indicate mechanical dilution or concentration of the lipoid emulsion, the cell volume of each specimen of blood was determined by Wintrobe's method.[16] Inasmuch as vacuum-dried heparin vials were used for collection of these samples, the usual correction for cell shrinkage due to sodium oxalate was omitted.

RESULTS

In Table I, the lipokrit and hematocrit results are tabulated for each of the twelve ether anesthesia patients. The sex, color, age, percentage over or under normal weight, diagnosis, operation, and quantity and duration of anesthesia are recorded for each patient. The patients are arranged in order of their deviation from normal weight, progressing from the thinnest to the most obese. It is interesting to note that the two highest fasting lipemia levels were found in thin peptic ulcer patients on Sippy diet. Correction of the lipokrit value for concentration or dilution according to the cell volume changes was found to indicate no significant alteration in total lipoid content of the serum (that is, no change greater than 40 ml. per cent, which is the least significant reading of the lipokrit scale). A study of Fig. 2 will show that there is no characteristic pattern in this group of twelve postoperative lipemia curves. There is a tendency for the curves of the obese patients and one underweight patient with gallstones to rise in the first four hours after operation; but the rise could not be considered significant in any case. There is a tendency for all curves to fall at the eight-hour postoperative interval and most of them continue to drop throughout the twenty-four-hour period. The degree of fall, however, is in no case greater than we have already found in

normal fasting alimentary lipemia curves. The curves are well grouped within the normal fasting lipemia range (427 ml. per cent to 703 ml.

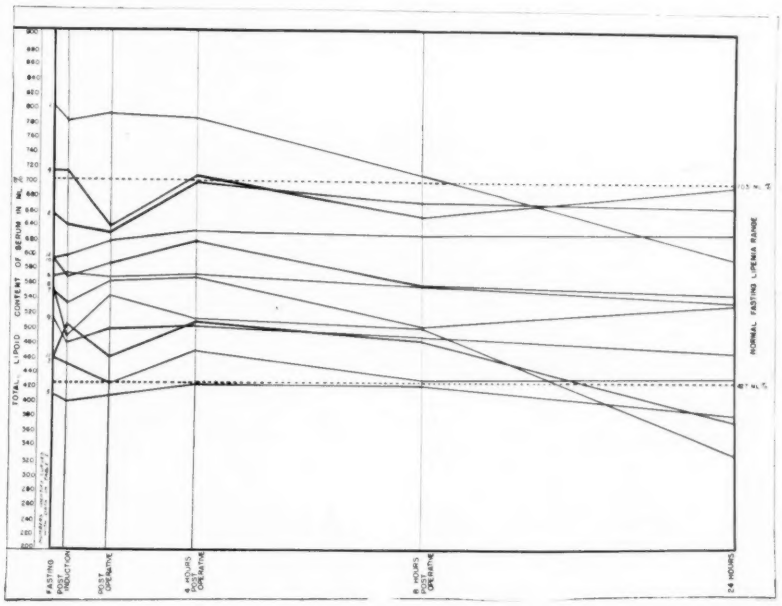
TOTAL LIPOID CONTENT OF SERUM IN ML. PER CENT
NORMAL FASTING LIPEMIA RANGE
FASTING POST REDUCTION
POST OPERATIVE
4 HOURS POST OPERATIVE
8 HOURS POST OPERATIVE
24 HOURS

Fig. 2.—Lipemia curves of twelve patients operated upon under ether anesthesia.

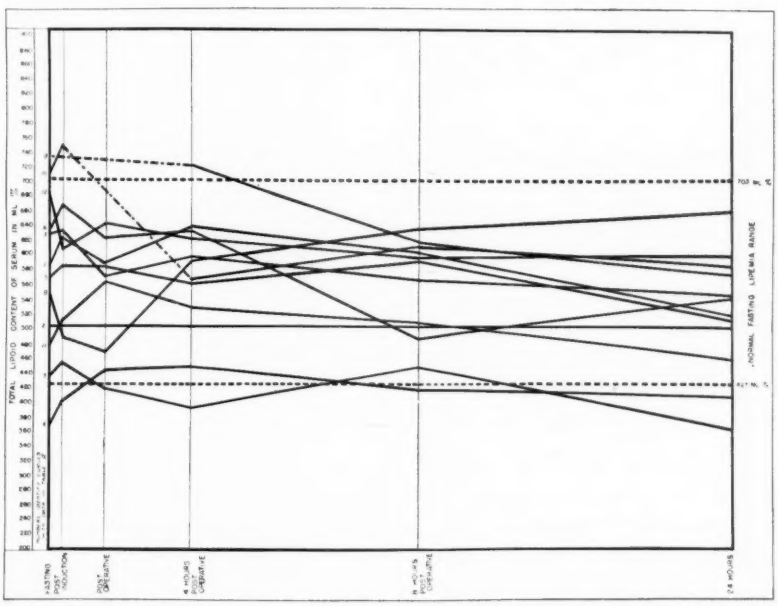
TOTAL LIPOID CONTENT OF SERUM IN ML. PER CENT
NORMAL FASTING LIPEMIA RANGE
FASTING POST REDUCTION
POST OPERATIVE
4 HOURS POST OPERATIVE
8 HOURS POST OPERATIVE
24 HOURS

Fig. 3.—Lipemia curves of twelve control patients operated upon under anesthetics other than ether.

per cent), and again it is interesting to note that the only curves projecting above this range are those of the two patients who had been on a Sippy regime for several weeks.

TABLE I

LIPOKRIT AND HEMATOCRIT DETERMINATIONS IN THE 12 ETHER ANESTHESIA CASES

DATA PERTAINING TO PATIENTS COLOR, SEX, AGE, PER CENT OVER OR UNDER WEIGHT, DIAGNOSIS, OPERATION, DURATION, ANESTHETIC, DOSE	TOTAL LIPOID CONTENT OF SERUM IN ML. PER CENT CELL VOLUME IN PER CENT					
	F.*	P.I.*	P.O.*	4 HR.	8 HR.	24 HR.
W., M., 36, wt. - 25%; ulcer obstructing pylorus; posterior gastrojejunostomy, 1 hr.; ether 600 ml.	805 44	785 44	795 47	790 44.5	715 44.5	600 39
W., F., 40, wt. - 18%; cystic duct calculus-hydrops; cholecystectomy, choledochotomy, 2 hr.; ether 650 ml.	655 45	640 45	630 46	700 48	675 47	670 46
B., F., 31, wt. - 10%; chronic salpingitis; salpingo-oophorectomy, right, 1 hr.; ether 540 ml.	460 40.5	450 39	425 38.5	470 40.5	430 39.5	435 39.5
W., M., 39, wt. - 10%; duodenal ulcer; Finney pyloroplasty, 1½ hr.; ether 600 ml.	715 49	715 48	640 48.5	710 51	655 49.5	700 47
B., F., 23, wt. - N.; retroversion of uterus; Gilliam suspension, appendectomy, ½ hr.; ether 150 ml.	410 49	400 48	410 47.5	425 50.5	425 49	385 49.5
B., M., 23, wt. - N.; bullet wound femoral artery; amputation gangrenous leg; ½ hr.; ether 90 ml.	570 19	575 19.5	570 19.5	575 19	560 17.5	540 19.5
B., M., 39, wt. + 5%; radial N. injury—fracture; neurolysis, open reduction, 2 hr.; ether 400 ml.	550 38	535 38	565 40	570 40	505 36.5	535 37
B., F., 23, wt. + 10%; chronic salpingitis; bilateral salpingectomy, 1 hr.; ether 200 ml.	560 40	490 38	545 38.5	515 41.5	505 40	330 42.5
B., F., 42, wt. + 15%; fibromyomata of uterus; panhysterectomy, 1½ hr.; ether 315 ml.	515 26.5	480 27.5	500 28	505 28.5	490 29	470 29
W., F., 49, wt. + 20%; cystocele, rectocele; perineorrhaphy, Gilliam suspension, 1½ hr.; ether 375 ml.	595 50.5	570 49.5	590 49.5	620 49.5	560 49	550 50
W., F., 49, wt. + 40%; chronic cholecystitis; cholecystectomy (calculi), 1 hr.; ether 600 ml.	455 49.5	505 49.5	460 50	510 52	485 49.5	375 50
W., F., 60, wt. + 80%; carcinoma of body of uterus; panhysterectomy, 1¼ hr.; ether 375 ml.	595 46	600 47.5	620 47	635 46	630 46	635 48

*In Tables I and II the abbreviations F., P.I., and P.O. are used as follows: F. denotes that the specimen of blood was taken after 12 hours fasting; P.I. denotes that the blood specimen was taken immediately before the induction of the anesthesia; and P.O. denotes that the blood sample was taken at the close of the operation.

Table II gives the data for the twelve control patients subjected to operation under other forms of anesthesia. It will be seen that four patients received local procaine anesthesia; four were given spinal anesthesia; two received nitrous oxide inhalation anesthesia; and of the remaining two, one received ethylene and the other was given tribromethanol by rectum. Fig. 3 shows that there is even greater variation in the pattern of the lipemia curves of these control patients. It is interesting to note that in three of the four patients operated upon under spinal anesthesia the lipemia curve rose abruptly after injection of the spinocaine. However, this rise may have been an effect of ephedrine (3 c.c. of 3 per cent solution) injected intramus-

TABLE II

LIPOKRIT AND HEMATOCRIT DETERMINATIONS IN THE LOCAL, SPINAL, NITROUS OXIDE, ETHYLENE, AND AVERTIN CASES

DATA PERTAINING TO PATIENTS COLOR, SEX, AGE, PER CENT OVER OR UNDER WEIGHT, DIAGNOSIS, OPERATION, ANESTHETIC, DOSE	TOTAL LIPOID CONTENT OF SERUM IN MG. PER CENT CELL VOLUME IN PER CENT					
	F.	P.I.	P.O.	4 HR.	8 HR.	24 HR.
B., M., 57, wt. - 25%; secondary carcinoma of femur; thigh amputation; local, procaine, 1%.	585 37	625 37	590 36.5	640 35	605 32	520 30.5
W., M., 58, wt. - 13%; epigastric hernia; Mayo herniaplasty; local, procaine, 1%.	505 48.5	505 49.5	505 47.5	505 46.5	505 46.5	505 51
W., F., 53, wt. + 15%; umbilical hernia; Mayo herniaplasty; local, procaine, 1%.	570 31.5	585 32	585 32.5	575 33	495 31	515 31
B., M., 27, wt. + 17%; inguinal hernia; Ferguson herniaplasty; local, procaine, 1%.	365 47.5	400 49	445 48	450 47	420 49	410 52
W., M., 60, wt. - 20%; vesical calculus, cystitis; suprapubic cystotomy; spinal, 150 mg.	630 46	635 46	580 44	600 43.5	570 45.5	550 45.5
W., M., 57, wt. - 18%; hydrocele of tunica vaginalis; bottle operation; spinal, 150 mg.	635 46.4	670 48	625 47	635 47	490 45	545 46
B., M., 58, wt. - 10%; hypertrophy of prostate; bilateral vasectomy, cystotomy; spinal, 150 mg.	435 40.5	455 40.5	420 39	395 38.5	450 40.5	365 38
W., M., 63, wt. + 13%; gangrene of toes, diabetes; thigh amputation; spinal, 150 mg.	545 43	490 40	470 39	595 47	635 45	665 45.5
W., F., 41, wt. + 69%; cystocele, prolapse of uterus; Watkins' interposition operation; nitrous oxide.	735 46	* 46	* 42.5	725 42.5	625 41	575 39.5
B., F., 74, wt. - ?; gangrene of foot, arterial sclerotic; thigh amputation; nitrous oxide.	710 38	750 37	* 36	570 31.5	615 34.5	590 38.5
W., M., 27, wt. - 5%; acute appendicitis; appendectomy; ethylene.	475 47	510 46	565 48.5	530 49	510 50	460 46
W., M., 61, wt. - 18%; inguinal hernia, recurrent; herniaplasty with Gallie suture; avertin.	685 46.5	610 46	645 46.5	625 45.5	600 45.5	605 44.5

cularly prior to administration of the spinocaine. The only curve which projects above the normal fasting lipemia range was that of an extremely obese patient who was subjected to a Watkins interposition operation under nitrous oxide anesthesia. Unfortunately, some of the values for the lipokrit determinations in the nitrous oxide anesthesia cases are not available because of breakage during centrifugation. Considered as a whole, however, this group of control postoperative lipemia curves is well within the limits of the accepted normal fasting lipemia range.

SUMMARY

1. This study of the twenty-four-hour lipemia curve of twelve patients subjected to various surgical operations under ether anesthesia

shows no typical curve pattern or tendency when compared with the curves obtained in twelve patients operated upon under other forms of anesthesia.

2. In none of the twenty-four patients studied did the lipemia curve project significantly beyond an arbitrary normal fasting lipemia range.

REFERENCES

1. Lehman, E. P., and Moore, R. M.: Fat Embolism Including Experimental Production Without Trauma, Arch. Surg. **14**: 621, 1927.
2. Lehman, E. P., and McNattin, R. F.: Fat Embolism Pathology of Lungs in Experimental Fat Embolism, South. M. J. **22**: 201, 1929.
3. Gage, S. H., and Fish, P. A.: Fat Digestion, Absorption and Assimilation in Man and Animals as Determined by Dark-Field Microscope, Am. J. Anat. **34**: 1, 1924.
4. Day, M. G.: Some Studies of the Blood Before and After Etherization by the Drop Method, Am. J. Surg. **36**: 53, 1922.
5. Potter, D. G. E.: Changes in the Blood in Anesthesia, Quart. J. Med. **18**: 261, 1925.
6. Mahler, A.: Blood Cholesterol During Ether Anesthesia, J. Biol. Chem. **69**: 654, 1926.
7. Reicher, K.: Chemische-experimentelle Studien zur Kenntnis der Narkose, Ztschr. f. klin. Med. **64-65**: 242, 1908.
8. Bloor, W. R.: Studies on the Blood Fats, J. Biol. Chem. **19**: 1, 1914.
9. Mann, F. C.: Some Bodily Changes During Anesthesia, J. A. M. A. **67**: 172, 1916.
10. Ducceschi, V.: Cholesterol of the Blood in Intoxication by Ethyl Ether and Chloroform, Chem. Ab. **14**: 1713, 1920.
11. Kinoshita, Tetsu: The Influence of Chloroform and Ether Inhalation Anesthesia on Different Constituents of the Blood of the Rabbit, Chem. Ab. **26**: 5346, 1932.
12. Ghose, A. C.: The Blood Cholesterol in Anesthesia, J. Physiol. **77**: 97, 1933.
13. Hospers, C. A.: Effect of Various Anesthetics on the Cholesterol and Sugar Content of the Blood, Arch. Surg. **26**: 909, 1933.
14. Herrmann, L. G., Ames, A., and Tapke, R. J.: Observations Upon the Lipokrit Method for the Determination of the Lipoid Content of Blood, J. Lab. & Clin. Med. **19**: 411, 1934.
15. Rückert, W.: Eine einfache volumtrische Mikrobestimmung des Blutfettes (Lipokritverfahren), Klin. Wchnschr. **10**: 1853, 1931.
16. Wintrobe, M. M.: A Simple and Accurate Hematocrit, J. Lab. & Clin. Med. **15**: 287, 1929.

THE DIAGNOSIS AND SURGICAL TREATMENT OF PERFORATING LESIONS OF THE COLON*

CLAUDE F. DIXON, M.D., AND HARRY M. WEBER, M.D., ROCHESTER, MINN.

(From the Division of Surgery and the Section on Roentgenology, the Mayo Clinic)

GENERAL CONSIDERATIONS

IT IS useful and proper to regard those lesions of the large intestine with which the idea of "tumor" is in any way associated as being of neoplastic or of nonneoplastic nature. The neoplastic lesions are the true blastomas, tumors in the more specific and apparently more widely accepted use of the word. The nonneoplastic tumefactions are inflammatory processes, resulting from infection by microorganisms, to the presence of which the reactive submucosal and serosal intestinal tissues respond in a highly productive manner, giving origin to the idea of tumor, but in its broader and strictly etymological sense. The inflammatory tumefactions are known also as infectious granulomas and pseudotumors of the intestine.

Analyzing these processes further, the neoplastic lesions may be subdivided according to histologic type, the nonneoplastic tumefactions on the basis of etiology and pathogenesis, as in Table I.

What some may consider to be a somewhat unconventional way of regarding these intestinal tumefactions is to be assumed if the term perforating lesions is to be applied to them. The nonneoplastic tumefactive lesions are, without exception, infectious processes. The microorganisms causing them gain access to the submucosal and serosal intestinal tissues most frequently by penetrating the mucosal surface, which is accomplished the more easily, of course, if that surface has been damaged by disease or trauma. Less relevant to this part of our discussion are the other possible avenues of infection, namely, through the serosal surface by extension from a contiguous inflammatory lesion, and embolically, from a more remote focus. Thus the nonneoplastic tumefactive lesions are considered to be essentially perforative in character, the neoplastic only potentially so. Almost any neoplasm projecting into the intestinal lumen is an infected lesion. If it is an infiltrating process, as the malignant neoplasms are, the infection is carried to the deep tissues with advancing neoplastic growth. Infection of the submucosal tissues occurs also as a result of the trauma to which neoplasms, both benign and malignant, as well as the mucous membrane immediately adjacent to them, are notoriously subject. It

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TABLE I

CLASSIFICATION OF TUMEFACTIVE LESIONS OF THE INTESTINE

A. Neoplastic: the true blastomas

I. Malignant:
Carcinoma
Sarcoma

II. Benign:
A heterogenous histologic group including *adenoma, lipoma, fibroma, myoma, hemangioma,* and even chondroma and osteoma

B. Nonneoplastic: inflammatory tumefactions

I. Primary:
(1) Hyperplastic ileocolitis, typhlitis, and pericolitis, the etiology of which is:
(a) Known: tuberculous, amebic, streptococcic, actinomycotic, rarely syphilitic, typhoidal
(b) Unknown: fibroplastic appendicitis, other inflammatory tumefactions
(2) Diverticulitis

II. Secondary:
(1) To extension of inflammatory processes from adjacent or contiguous abdominal organs: gallbladder, ovaries and ovarian tubes, seminal vesicles, omentum, mesentery
(2) To segmental injury (foreign bodies, coproliths, circulatory disturbances)

is conceivable, then, that the same microorganisms which cause the inflammatory intestinal tumors may utilize the site of mucosal damage incident to neoplastic disease as a convenient portal of entry into the more reactive tissues of the intestinal wall, there to incite the development of a lesion of dual nature, having neoplastic as well as inflammatory components. Once instituted, the inflammatory process not infrequently succeeds in its tendency to overwhelm the original neoplastic lesion to such an extent that the fairly distinctive, gross morphologic features of the neoplastic lesion are altered to resemble, in almost every particular, the very much less readily appraised gross morphologic features of the purely inflammatory tumors. With this change in form and structure there is a corresponding change in clinical and roentgenologic manifestations, so that ultimately the entire syndrome is that of a nonneoplastic, rather than that of a neoplastic, lesion.

It seems not unreasonable to assume that any neoplastic lesion of the intestine will eventually be attended with perforative-inflammatory manifestations, provided only that it be permitted to go its own way for a sufficient length of time; and the higher the grade of malignancy the greater will be the tendency in this direction. Another factor certainly encouraging perforation is the obstruction incident to the presence of a neoplastic lesion. Whether due to gradual reduction in luminal caliber by increasing encroachment of the neoplastic substance, or to the tendency toward intermittent or persistent, partial or complete intussusception which all neoplasms seem to have in some degree, obstruction evokes increased peristaltic activity. This in turn

produces increased intraluminal pressures, sufficient in many instances to break or split the indurated neoplastic tissue which is rendered the more frangible the more infected it is.

Such is the origin and development of our conception of the perforating lesions, a term applicable to the purely inflammatory tumors on the one hand, and to the neoplastic lesions, when complicated by inflammation of sufficient degree to obscure their otherwise distinctive morphologic characteristics, on the other. From the standpoint of surgical management, the coexistence of this amount of inflammatory reaction with a neoplastic lesion not only confuses the diagnostic problem, at least until such time as a proper section of the diseased tissue can be submitted for microscopic examination, but it also imposes operative difficulties and hazards otherwise not encountered. The freedom with which the diseased segment of intestine can be handled, either as it is explored or as it is mobilized in the course of an operative procedure, is greatly limited, both because some degree of fixation is always to be found, and because injudicious manipulation certainly promotes spread of the already existing, but presumably localized, peritonitis.

THE ROENTGENOLOGIC DIAGNOSIS

The treatment and prognosis in tumefactive lesions of the large intestine are conditioned primarily on whether they are of neoplastic or of nonneoplastic nature. Since it has been found that roentgenologic methods can be made to be so very efficient in establishing this vitally important differentiation, this phase of the diagnosis is to receive, in the discussion that is to follow, a particular, but it is hoped not disproportionate, emphasis. The lesions of the rectum and lower sigmoid within reach of the proctoscope are left out of consideration here for the reason that no less direct diagnostic method could conceivably be more accurate and reliable than the competently performed proctoscopic examination is in the diagnosis of these lesions. The roentgenologic examination competently performed takes precedence over all other diagnostic methods applied to the colon for the same reasons, namely, that its diagnostic elements are such that they enable the examiner to reconstruct in his mind's eye the gross morphologic features of the lesions he exhibits, and to interpret them in terms of pathologic anatomy.

It may be affirmed that the roentgenologic examination can be made to reveal the presence of any tumefactive lesion of the large intestine, at least as early in its development as it is able to manifest itself by clinical signs and symptoms. Such lesions are exhibited roentgenologically by producing what is called a filling defect, which may be defined as a constant, persistent subtraction from the normal contural outlines. It is produced chiefly by protrusion of the tumefactive substance

toward and into the lumen, partly by diminished distensibility of the infiltrated wall. It is a manifestation of diseased but living tissue, hence certain changes in appearance are to be expected as a result of a possible, not entirely interrupted, intestinal motility. The filling defect corresponds to the intraluminal contours of the lesion which is its cause, and the roentgenologic diagnosis is based upon such morphologic features of the filling defect as reflect the pathologic anatomy of the lesions capable of producing them.

Carcinoma of the large intestine is manifested roentgenologically by signs so consistently distinctive that they are considered to be only slightly less pathognomonic than the gross morphologic picture itself.

The typical neoplastic filling defect is always confined to a relatively short intestinal segment, and describes a more or less marked, but relatively pervious, narrowing of the lumen. The canal through the neoplastic substance may have smooth tubular contours. Its course may be straight or irregularly angular, but almost always it is somewhat eccentric to the normal intestinal lumen proximal and distal to it. A most significant feature is the abrupt demarcation between involved and uninvolved intestine (Fig. 1). A mucosal relief pathognomonic of neoplasm can be described; and this is the most fundamental, the most reliable, and the most generally applicable, although not the most easily elicited, of all the roentgenologic signs of neoplasm of the colon.

Different histologic and gross morphologic types of carcinoma present different intraluminal relief patterns, but the normal relief is always entirely obliterated. Often, especially with the annular or fibroscirrhous carcinomas, the internal aspect of the involved segment is flat and roughly granular and there is a peculiar stiff rigid look about it. Other types of carcinoma exhibit this granular surface also, but associated with it is a disordered arrangement of irregular depressions and elevations, resulting in a gnarled, coarsely-jagged relief. Polypoid carcinoma produces a marginal filling defect only when ulcerated, in which case the relief pattern reflects its saucerlike form; but again the granular amorphous character of the surface is apparent, broken irregularly by elevations corresponding to the excrescences of carcinomatous substance on the surface. Invariably apparent, however, and the most telltale feature of the neoplastic relief pattern, is the abruptness with which it is delimited from the uninvolved mucosa proximally and distally contiguous to it (Fig. 2). An expression of this sharp delimitation is the seemingly persistent tendency of the unperforated, neoplastic lesion toward intussusception. This is manifested roentgenologically by the appearance of unilateral or bilateral crescentic spurs at the proximal or distal extremity of the channel, or both, at the time when the lesion and the adjacent intestine are well distended with contrast material. This crescentic shadow complex is interpreted as an effort of the lesion to insert itself into the lumen of the bowel,

or as an attempt of the contiguous intestinal wall to fold itself around the tumor. Whatever the interpretation of this phenomenon is, only neoplastic lesions exhibit it, and it is a pathognomonic roentgenologic sign, particularly valuable when the channel is apparently or really impervious to injected or orally administered contrast material.

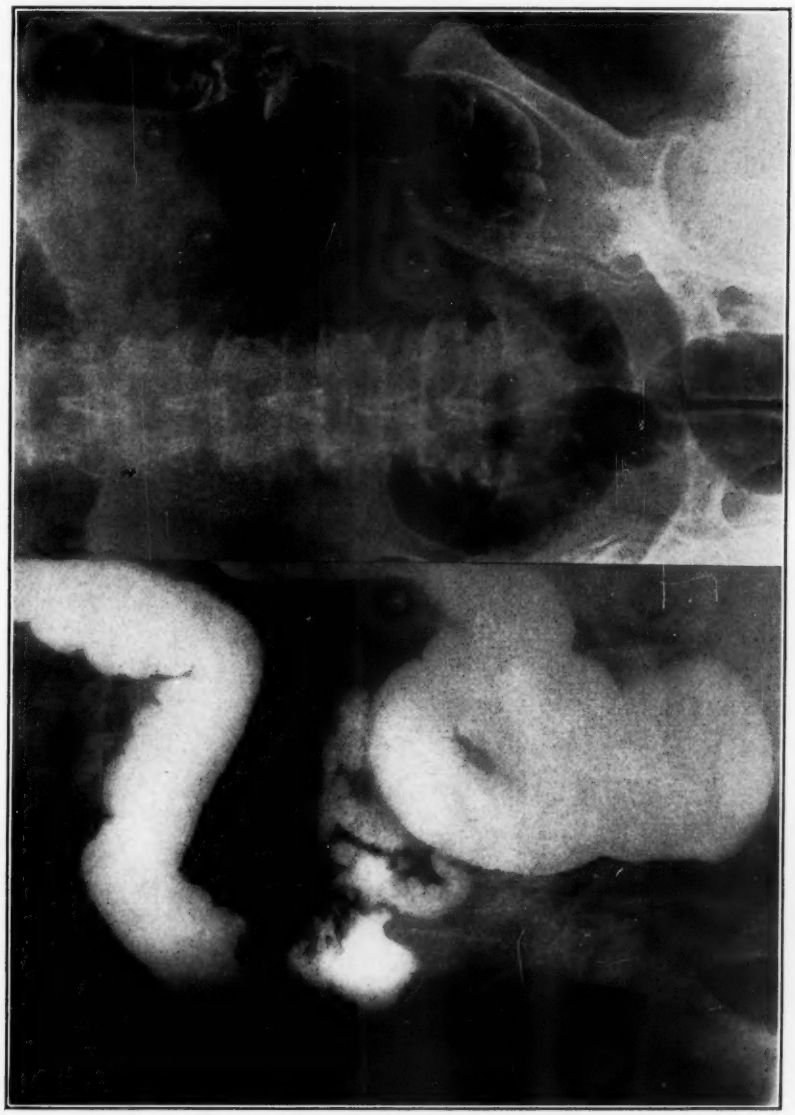

Fig. 1.—Typical filling defects produced by carcinoma; *left*, ascending colon (opaque enema); *right*, descending colon (double contrast method).

The typical nonneoplastic filling defect is best defined as one in which the pathognomonic evidences of true neoplasm are lacking. It is essentially a constriction of the lumen, embracing only a part of one of the divisions of the large intestine, but it usually is a longer defect than the one associated with neoplasm (Fig. 3). The amount of constriction also varies within considerable limits. Some inflammatory tumors

Fig. 2.—The characteristic relief pattern of carcinoma: *left*, sigmoid colon; *right*, ascending colon.

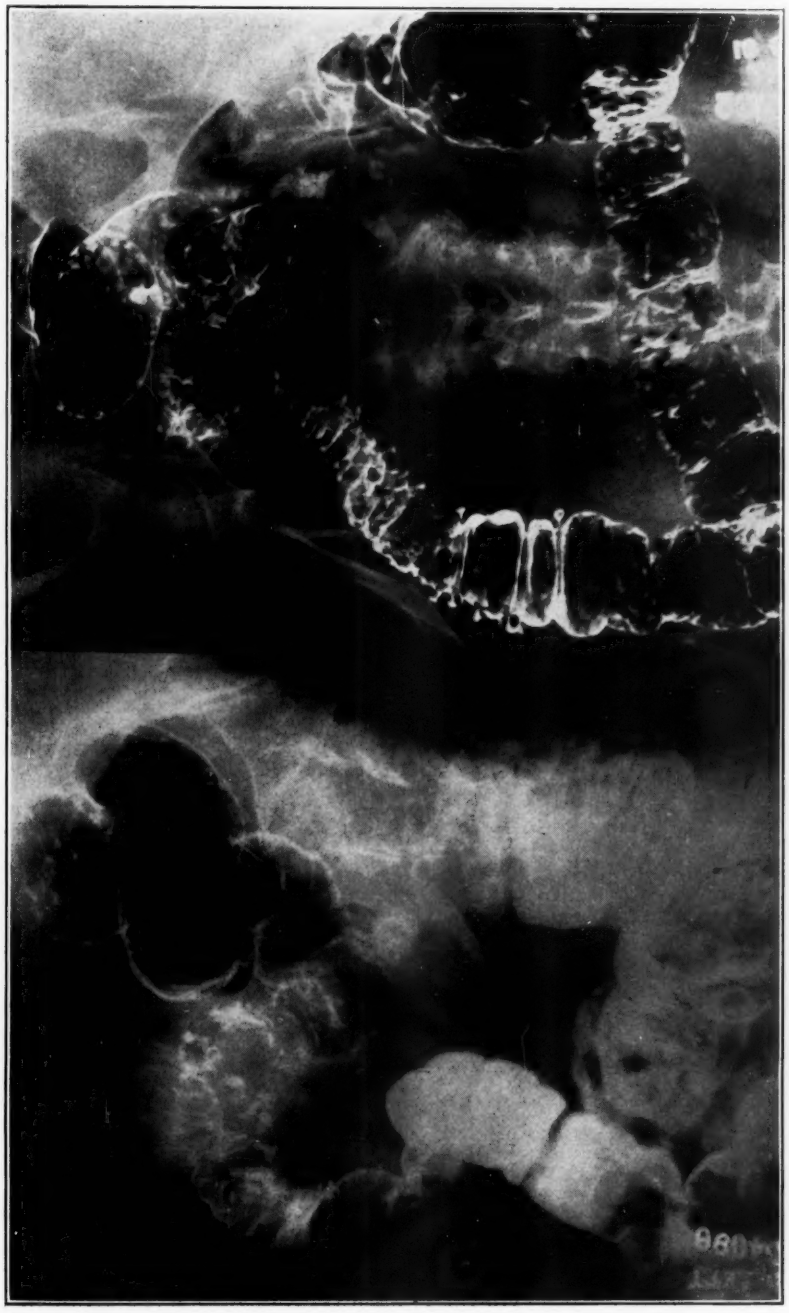

Fig. 3.—Typical filling defects produced by nonneoplastic tumefactions (double contrast method): *left*, diverticulitis; *right*, tuberculoma. Both lesions are in the sigmoid colon.

narrow the lumen to such an extent as to render it entirely impervious, while others, of the same etiology, produce a narrowing which is hardly perceptible. Inflammatory disease in general is progressive and to a certain extent self-limited, and the gross morphologic as well as roentgenologic appearances depend largely on the stage of development at which the lesion is observed.

As has been indicated, neither the length of the filling defect nor the amount of constriction is constant, but all inflammatory tumors are alike in this respect that the filling defects they produce all fade off gradually, almost imperceptibly, into the normal contours of the intestine proximal and distal to the constricted area. Destruction of the mucosa may or may not take place, and when it is observed it is practically always in association with those inflammatory tumors caused by an etiologic agent which under other circumstances causes ulcerative colitis. The tuberculous, amebic, and the streptococcic granulomas are the principal examples of this group of inflammatory tumefactions. The most important pathologic changes are found in the submucosal structures; and while the mucosa has always undergone some pathologic change, it may be unbroken throughout the entire extent of the lesion. Combined involvement of ileum and cecum is commonly seen when an inflammatory tumor involves this region, a phenomenon never seen with neoplasm unless perforation has taken place. All of these morphologic features are reflected faithfully in the roentgenologic picture, but after all is said and done, the diagnosis of inflammatory tumor is made by eliminating the possibility of neoplasm as the underlying lesion.

When the roentgenologic examination has demonstrated that a tumefactive lesion is present, and has offered its dependable conclusions about the neoplastic or nonneoplastic nature of the tumor, it has made about as great a contribution to the final diagnosis as may be expected of it. There are no fundamentally reliable roentgenologic signs by which the various etiologic types of inflammatory tumor can be distinguished from each other, and the final roentgenologic diagnosis often, if not usually, reads "nonneoplastic tumefaction of indeterminate etiology." This noncommittal phrase is useful in that it does not bind the roentgenologic examiner to extend his diagnosis beyond the limitations of his method of investigation, although it is often possible, by keeping all the etiologic types of inflammatory tumefaction in mind and correlating these with a carefully elaborated clinical survey of the patient, to approximate the exact nature of a given lesion very closely.

The filling defect produced by neoplastic lesions which have perforated or which have otherwise been complicated by infection looks much more like the filling defect of the inflammatory tumors than like that of the true neoplasms (Fig. 4). As a result of the pericolic inflammatory process which is set up, the filling defect occupies a much

Fig. 4.—Filling defects produced by perforating carcinoma with development of huge pericolic abscess: *left*, transverse; *right*, sigmoid colon.

longer segment of bowel than does the original lesion. The sharp demarcation between involved and uninvolved intestine disappears, and the filling defect tapers off gradually into normal external contours. Proximal and distal to the site of the original lesion, the mucosal pattern is markedly disturbed but not destroyed, and it is similar in almost all respects to that seen in association with inflammatory tumefactions. The tendency toward intussusception disappears. Diacritical roentgenologic signs of the original lesion are not, however, obliterated beyond the point where roentgenologic methods fail to

Fig. 5.—Perforating carcinoma of the sigmoid colon: between brackets is the poorly demarcated filling defect; between arrows, the characteristic neoplastic relief pattern of carcinoma.

redeem them, and it is here that familiarity with the internal relief of the neoplastic lesion is of particular value. Situated often at or near the precise midpoint of the filling defect is an area manifesting a relief entirely different from that immediately proximal and distal to it, the pathognomonic internal relief of neoplasm, a frankly inadequate description of which was attempted above (Fig. 5).

The fundamental importance of obtaining adequate visualization of the entire extent of the filling defect, and of making a most careful study of the structural detail of its internal relief, should, in view of

what has been said, be obvious. To do this, antispasmodic drugs, administered to full physiologic effect, are often useful in diminishing the increased irritability associated with these lesions. Often, too, roentgenologic examination after a short therapeutic regimen directed at alleviating the inflammatory component of the filling defect will permit the establishment of a diagnosis, otherwise of necessity left indeterminate. It may be said that a dependable roentgenologic diagnosis of neoplasm with perforation can be made whenever it occurs, and to confuse the condition consistently with the nonneoplastic tumefactions is to fail to exact the full diagnostic yield of the roentgenologic examination.

SURGICAL CONSIDERATIONS

We have given such lengthy and detailed consideration to the roentgenologic phase of the diagnosis, not in any sense to detract from the value of carefully and competently performed nonroentgenologic diagnostic maneuvers, but to emphasize the value of the roentgenologic method, to point out its work and its limitations, and to show why the classical roentgenologic signs of neoplasm fail when infection and neoplasm are intimately associated in the same lesion. Clinical signs and symptoms, although more indirect, may in certain instances be all but pathognomonic, but they are always of great value. Bargen and one of us (Dixon) have described certain features of perforating neoplasm which have been of great diagnostic utility. One of these is the character of the reaction following the preoperative intravenous administration of a vaccine prepared from *Bacillus coli* and streptococci. The normal reaction, in the presence of nonperforating lesions of the colon, is an elevation of the temperature of the body from normal to 101 degrees to 103 degrees F. within ten to twelve hours. The temperature returns to normal abruptly and remains so after sixteen to seventy hours. If a perforating lesion is present, the reaction is characterized by a saw-tooth type of fever curve, the temperature of the body ranging from normal to 102 degrees F. for from three to six days. A similar reaction seems to be evoked by metastatic lesions in distant organs. To apply this best, of course, the existence of an intestinal neoplastic lesion must have been previously determined. It indicates inflammatory involvement of the peritoneum rather than the lesion which may have been its cause.

As indicated previously in this discussion, the coexistence of infection and neoplasm entails difficulties not encountered if the lesion is purely neoplastic or purely inflammatory. Whether complicated by infection or not, neoplastic lesions demand radical treatment, yet the very presence of infection may seriously impede the institution of the more radical surgical procedures indicated. The infectious as well as the neoplastic component of the perforated neoplasm must be given serious consideration, and the surgical management, while aimed

directly at extirpation of the neoplastic process, is modified to minimize the added danger to the patient which the infectious component imposes.

The surgical treatment of diverticulitis provides an exemplification of these principles. In many instances this condition may be treated satisfactorily without surgical intervention. A combination of a low residue dietary regimen, methods of applying local heat, and antispasmodic drugs administered liberally often effects subsidence of the inflammatory process within reasonable limits of time.

The formation of pericolic abscess with and without extension to adjacent pelvic viscera, especially to the urinary bladder with the development of sigmoidovesical fistula, are among the more frequent complications of diverticulitis. Occasionally the pericolic abscess will drain spontaneously into the bowel and subside. If this fails to occur and the symptoms suggest that the abscess has become localized, institution of abdominal drainage is indicated. Fecal fistula may develop following such drainage and necessitate surgical treatment such as segmental resection. Spontaneous closure of the fistula may follow establishment of a temporary colonic stoma without direct attack on the fistula itself. After closure of the fistula, the continuity of the bowel can be reestablished.

Surgical treatment is usually necessary to bring about closure of a sigmoidovesical fistula. Here a temporary colonic stoma is made well above the fistulous opening in the bowel. Subsequently the involved segment of intestine is resected and the ends are brought together by end-to-end anastomosis. The opening into the urinary bladder is frequently circumscribed by so much induration that wide excision of that portion of the wall of the bladder is necessary. A suprapubic cystic stoma is usually established in these cases. The colonic stoma is closed later.

In the surgical treatment of intestinal tumefactions, it seems worth while to remark briefly about the use of intraperitoneal vaccine preoperatively. Accumulating experience seems to indicate that by this means the mortality from intestinal surgery is appreciably reduced. Intraperitoneal vaccination is therefore recommended. Some deaths from peritonitis still occur, of course, but in our experience their number has been strikingly lowered. If gross contamination occurs during an operation on the intestine, the insult to the peritoneum may be too great for it to overcome. In instances of contamination, anaerobic serum, as suggested by Weinberg, of the Pasteur Institute, for the treatment of peritonitis following perforation of the appendix, has been employed for the past two or more years. His studies showed that anaerobic microorganisms such as *Clostridium welchii*, *Bacteroides ramosus*, *Vibrio septicus*, and some others played important parts in the production of the peritonitis, and these findings have been con-

firmed by other workers in Germany, France, and Japan. Many European surgeons have published reports indicating that the use of such antianaerobic serums has reduced the death rate from generalized peritonitis accompanying or following perforating appendicitis very appreciably. Our own observations lead to the belief that the death rate following removal of perforated lesions of the intestine has also been reduced as a result of the use of these serums. It is realized that evaluation of such experience is difficult, but vaccination has a logical appeal, and it appears that further use of the vaccine is recommendable since there is considerable evidence that the presence of certain anaerobic organisms creates a favorable environment for the growth of streptococci, *Escherichia coli*, and other aerobes which are commonly lethal in peritonitis. It seems probable that anaerobic organisms may be responsible for a greater number of fatal infections following resection of the colon than has heretofore been suspected.

Experience also indicates that the operative mortality can be reduced still more if some kind of short-circuiting operation is carried out before the diseased segment of intestine is resected. This encourages the subsidence of the concomitant inflammation, and this in turn facilitates the resection itself. Short-circuiting or sidetracking procedures are of particular advantage if the perforating lesion is situated well above the sigmoid colon. Ileocolostomy is done for lesions of the right half of the colon, and colocolostomy for those in the left half. As a rule such operations are not employable for lesions of the sigmoid or lower pelvic colon, because, if the greatest care is not exercised, contamination will occur when the lesion is subsequently removed. Preferably, the parietal peritoneum attached to the lesion is liberated and left as a patch over the lesion. This serves to prevent not only gross contamination, but also malignant implantation at the site of a possible "blowout." In cases in which this technic was employed, no attempt was made to approximate the peritoneum over the exposed muscle.

If feasible, perforating lesions of the colon are most satisfactorily managed by using a short-circuiting procedure as the first stage of the operation. If the lesion is in the pelvic colon or sigmoid, the portion of the parietal peritoneum involved in the inflammatory mass is to be freed with the lesion and used as a patch to prevent gross contamination. The use of anaerobic serum is recommended only because some of the fatal peritoneal infections following operations on the colon have, with apparent justification, been attributed to anaerobic microorganisms.

REFERENCES

1. Bargen, J. A., and Dixon, C. F.: The Management of Peritonitis—Based on New Conceptions, Southwestern Med. **19**: 391-394, 1935.
2. Weinberg: Indirect communication to the authors.

Editorials

One-Stage or Plural-Stage Operations

A NOTEWORTHY advance has been achieved in many fields of surgery by the division of a surgical procedure into two or more separate operations. By this device the mortality of certain formidable situations has been definitely lowered, and other conditions that seemed too forbidding to justify surgical attack have yielded to such treatment with encouraging results. The principle has been widely applied in many diverse surgical domains. It may suffice to point out the highly toxic group of thyroid disease, various thoracic conditions, many plastic problems, and malignant disease of the alimentary tract.

It is perhaps inevitable that a method of demonstrated value should for a time, and by some surgeons, be utilized when it is not needed and where it is indeed unwise. The writer feels that something of the sort is happening now with the stage plan of operating and believes that a critical survey of the reasons for and against such a plan deserves a brief discussion. To choose a concrete example and a field with which the writer is most familiar, let us consider the case of malignant disease of the large bowel. Experience has demonstrated that direct attempts at removal of such tumors, when the patient is first seen while suffering with acute intestinal obstruction, are apt to result disastrously. The bowel above the obstruction is distended with highly toxic and infectious contents; its wall is edematous, with impaired circulation and often already invaded by bacteria; and the tissue is friable. Under such conditions, suturing or even excessive handling of the gut is fraught with great danger of peritonitis and general infection. In addition, the patient has all the constitutional disturbances that go with acute obstruction. It is not surprising that extensive resections in such a situation often turn out badly. Analysis of the disorder reveals the clear fact that the patient is suffering from two different although related conditions—acute intestinal obstruction and a tumor of the bowel—and that the former, an urgent emergency, has the right of way in treatment. The latter must wait for consideration until the emergency is past. It is obvious, therefore, that this clinical state calls for two divided surgical procedures: first, colostomy to relieve the obstruction; second, resection to remove the tumor; and separation of the first from the second operation by a period of time ample to permit complete recovery from the obstructive phase of the illness. The general acceptance of this division of the operative attack

has resulted in much improved results. It was soon extended beyond the cases first seen in acute, complete obstruction and was employed in the treatment of partially and chronically obstructed tumor cases. A perhaps natural further extension was the idea advocated by some very able and experienced surgeons that all cases of tumor of the colon should be operated upon in stages, a preliminary colostomy being done routinely before excision of the growth is undertaken.

Now it is this last phase of the development of the divided attack that challenges criticism. Let it be remembered that the original purpose of the two-stage procedure was to limit the surgical interference to dealing with obstruction. What rational excuse can be advanced for applying this technique to a case that presents no obstruction? It would seem that this is another instance of the common human trait of following an established custom without analysis of why the custom was established. The discriminating position to take in regard to a first-stage colostomy would be to limit it to those cases of tumor in which obstruction actually requires it. Experience has shown that many cases of low-grade, partial obstruction may be quite satisfactorily operated upon in one stage by adequate preparatory treatment to clear up the partial obstruction, and certainly with no obstructive symptoms there is no need for a two-stage procedure.

But the scope of this discussion is more general than a consideration of colostomy in tumors of the colon. It should be remembered that there are clear and obvious objections to plural-stage operations per se. Each separate operation carries with it a separate hazard of hemorrhage, infection, potential complications relating to anesthesia, and the rare accidents like embolism. In addition, multiple-stage procedures nearly always mean increased hospital sojourn with added expense, loss of time, anxiety and delay in convalescence. These are weighty objections and must be offset by even greater benefits to justify the division of the surgical treatment into stages. In many cases such benefits do exist, and then it is wise to plan treatment accordingly. It is in no sense the intent of this article to oppose the principle of stage operations. As has been said, the idea is valuable and marks a step forward in practical handling of many difficult situations. The purpose of this article is, however, to insist that there is no inherent virtue in multiple-stage operations; that, on the contrary, there are definite and obvious disadvantages inherent in every divided operation and that each individual problem should be clearly analyzed before it is decided that a one-stage attack is unwise. In other words, the burden of proof always lies against the plural-stage operation.

—Harvey B. Stone, M.D.
Baltimore, Md.

The Surgery of the Sympathetic System

THE traditional functions of operative surgery are, first, the adjustment of injured tissues to facilitate the processes of repair; second, drainage to make easier the body's struggle against invading bacteria; and, finally, the direct eradication of diseased structures. To these, modern surgical development has added a new conception: the indirect attack on disease by the surgical modification of physiologic balances. Current operations on the sympathetic nerves and ganglia furnish the outstanding example of such indirect attack.

It is easy to assume that the surgery of the sympathetic system is directed toward the cure of disease; i.e., that sympathetic imbalance is the essence of disease. This common assumption involves a conception for which there is no real evidence. The lesions of trauma, inflammation, and new growth, grossly and microscopically identified, may occur at single or multiple focal points in the autonomic system anywhere from the hypothalamic centers or higher to the most distant peripheral fibers, producing symptoms and signs resulting from paralysis or stimulation of autonomic functions. The therapy of these conditions is obviously in most instances the therapy of the underlying pathologic process. Except for such identifiable focal lesions, it is probably proper to say that there is no known pathology of the autonomic system. To speak of diseases of this system is, therefore, unwarranted.

If one reviews the mechanism of the vast majority of everyday symptoms, one realizes that almost all are produced by impulses passing over the autonomic pathways. Fever, chills, colic, vomiting, dysuria, constipation, diarrhea, sweating, hunger, thirst, palpitation of the heart, dyspnea, and many varieties of pain are all closely associated with autonomic activity. In the vast majority of instances we do not think of the autonomic nature of these manifestations. Our minds are directed rather to possible underlying causes such as pulmonary tuberculosis or intestinal obstruction. Today, it would be actually possible to cure the night sweats of tuberculosis by sympathetic denervation, and theoretically possible to abolish the colic of intestinal obstruction by parasympathetic neurectomy. Only when the etiology of the disease is obscure, are we led to focus our attention on the fact that symptoms are expressions of autonomic activity. This may be illustrated by a phase in the history of the treatment of exophthalmic goiter, when relief of the predominantly sympathetic symptoms by sympathectomy was proposed and in many instances carried out. It behooves us at least to raise the question whether our modern operations on the sympathetic nerves may not in the future prove to have an equally illogical basis.

These considerations lead to a conception of the rationale of sympathetic surgery which seems somewhat more logical than that involving an assumption of sympathetic disease. This conception may be simply expressed as follows: There is no known disease specific to the autonomic system; certain diseases, largely of fundamentally unexplained etiology, present sympathetic symptoms of importance in themselves; sympathectomy attempts to relieve these symptoms rather than to cure a disease. Such symptoms, of course, are illustrated by the Raynaud phenomenon, by the obstipation of megacolon, and by the elevated blood pressure of essential hypertension.

If this conception is preserved, three things will be accomplished. In the first place, a search for an underlying cause for unexplained disease will not cease. In the second place, we will save ourselves the embarrassing recollection of dogmatic statements that certain diseases have been cured, when in later years, after these diseases are better understood, we realize that relief of symptoms is all that has been effected. In the third place, we will tend to protect our patients from too extensive modifications of physiologic balance by sympathectomy for symptomatic relief alone.

The surgery of the sympathetic system, so far as present knowledge goes, must be thought of as being in the great majority of instances entirely symptomatic. When pathologic changes in the autonomic system are uncovered in association with the so-called sympathetic syndromes, this position can be modified.

Lastly, in maintaining this point of view, one need not minimize the value of sympathetic intervention. Skillfully applied to the relief of symptoms severe enough to warrant intervention, on indications intelligently developed and after adequate study, surgical attack on the sympathetic system offers a new factor in the therapeutic armamentarium of great present importance and perhaps even greater promise. Only let us recognize that when we attack the sympathetic, we attack symptoms and, in the light of present knowledge, not disease itself.*

Edwin P. Lehman, M.D.
University, Va.

*The ideas herein expressed have already been presented as a part of the chairman's address before the Surgical Section of the Southern Medical Association at its meeting in November, 1933.

Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

THE SURGICAL TREATMENT OF CORONARY DISEASE

ALTON OCHSNER, M.D., AND MICHAEL DEBAKEY, M.D., NEW ORLEANS, LA.

(From the Department of Surgery, Tulane University School of Medicine)

IT IS indeed remarkable that although Heberden[1] published his original disquisition concerning cardiac pain due to coronary artery disease in 1786, this important disorder was not clearly recognized until relatively recently, when Herrick[2] made his first important contribution in 1912. That a disease of such vital significance and relatively frequent occurrence, particularly among physicians,[3] should be relegated to almost complete desuetude for over a century and a quarter is extraordinarily amazing. However, during the past quarter of a century intensive anatomic, physiologic, and experimental investigations have established a more elucidative comprehension of the fundamental background of the malady and a more rational therapeutic approach.

The treatment of coronary artery disease and cardiac pain is of particular interest to the surgeon, because of its historical importance in the development of surgery of the sympathetic nervous system. The first successful clinical application of sympathectomy was based upon the ratiocinative speculations of Francois Franck,[4] in 1899, and performed by Jonnesco,[5] in 1916, in a case of angina pectoris. The successful result of this first operation stimulated universal interest and the procedure was quickly and widely adopted. The brilliance of this first successful result was soon dimmed by the many disappointing failures in the hands of other surgeons. As a consequence, various modifications were advocated and divergent theories proposed which only added to the already existing bewilderment and confusion. In the light of recent anatomic and physiologic advances, this was obviously due to inadequate knowledge and insufficient comprehension of the underlying fundamental principles.

The present status of the surgical treatment of coronary artery disease and cardiac pain involves a consideration of three main methods of attack: (1) the sympathetic nervous system; (2) the thyroid; and (3) the development of a collateral blood supply to the heart.

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THE SYMPATHETIC NERVOUS SYSTEM

The rationale of the surgical procedures which attack the sympathetic nervous system is based upon an interruption of cardiosensory and motor pathways. This was originally suggested by Francois Franck[4] and first clinically tested by Jonnesco.[5] The numerous and various procedures advocated following Jonnesco's operation clearly reveal their unsatisfactory results. In order to explain the inconsistent results and to understand better the rationale upon which this method of surgical attack is based, it is necessary to review the underlying anatomic and physiologic principles in the light of recent investigations.

The presence of typical somatic afferent fibers in the sympathetic cardiac nerves is now definitely established. The histologic characteristics of these fibers have been excellently described by Ranson and Billingsley[6] and Stöhr.[7] Heinbecker[8] has further corroborated this fact by utilizing the cathode ray oscillograph to demonstrate that their electrical conduction properties are similar to those of afferent fibers in the ordinary sensory nerve. Strictly speaking, these nerves are not a part of the autonomic nervous system at all, but they simply utilize the sympathetic pathways to the heart to transmit afferent impulses from the heart to the central connection.

The sensory nerve endings of the heart and aorta are similar to those found elsewhere and have been shown by Stöhr[7] to be present in the heart muscle, endocardium and epicardium, and in the adventitia of the coronary artery. The neurones to these sensory endings converge in the periarterial plexus of the coronary arteries, traverse the superficial and deep cardiac plexuses and course in the middle and inferior cardiac nerves which join the corresponding cervical ganglia of the sympathetic chain. As there are no white rami communicantes between the cervical sympathetic chain and the spinal cord, practically all of these outbound fibers must descend to the upper thoracic ganglia and finally reach their cells in the spinal ganglia by passing through the white rami communicantes into the central portions of the first thoracic and upper four or five intercostal nerves. Aside from the well-established cervical cardiac nerves, Brauecker[9] and Ionesco and Enachesco[10] have recently shown that there also exist thoracic cardiac nerves which run directly across the posterior mediastinum to the upper thoracic sympathetic ganglia; that is, the upper four or five thoracic sympathetic ganglia. All of the thoracic and cervical cardiac nerves carry somatic afferent fibers except the superior cardiac nerve, which Ranson and Billingsley[6] claim is a purely motor pathway. Thus, it can be readily observed that all of the sensory pathways from the heart converge on the upper four or five thoracic sympathetic ganglia (Fig. 1).

This concept of the cardiosensory pathways has been recently corroborated by experimental investigations. In 1930, Sutton and Lueth[11]

published the results of their studies on the production of cardiac pain in dogs. They were able to produce the characteristic signs of pain in the normal dog by temporarily constricting the descending branch of the left coronary artery, and showed that these signs would rapidly disappear when the constriction was relieved. Utilizing a similar procedure to study experimental pain conduction, White, Atkins, and Garrey[12]

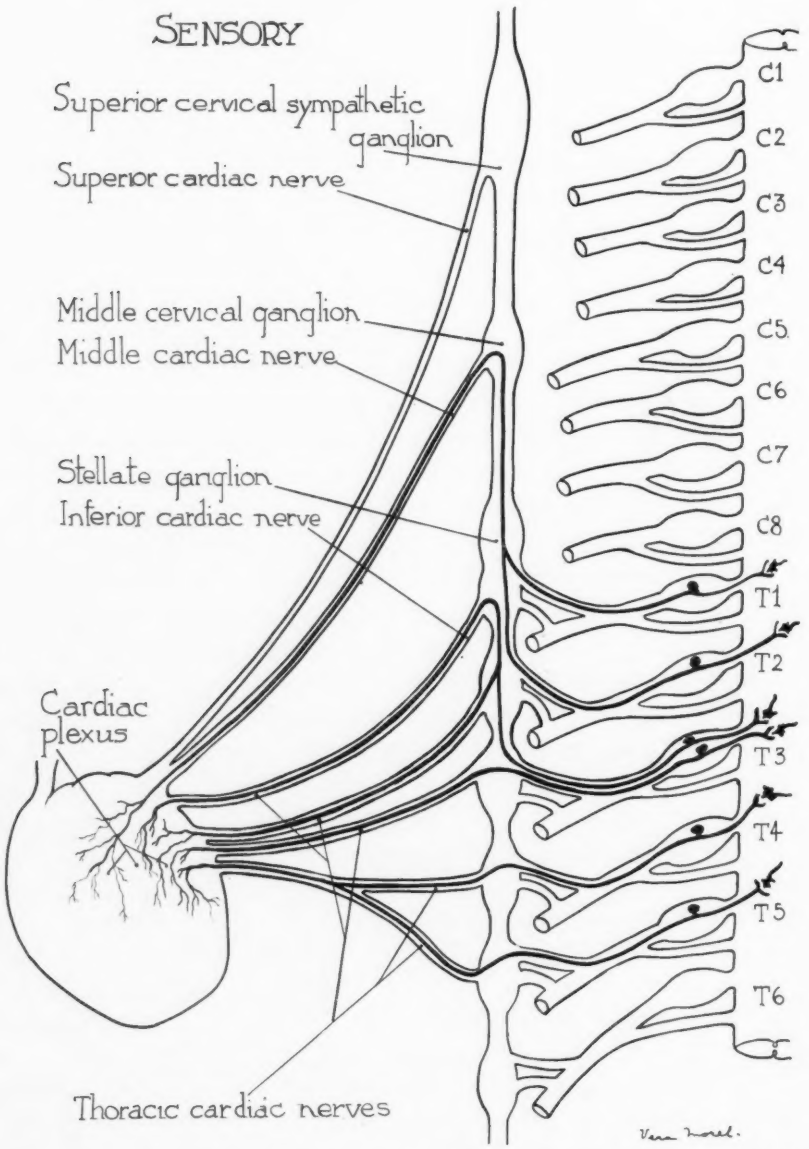


Fig. 1.—(Modified after Kuntz, Albert: Autonomic Nervous System, Philadelphia, Lea & Febiger, 1934, and White, J. C.: The Autonomic Nervous System, New York, The MacMillan Company, 1935.) Diagrammatic representation of the cardiosensory pathways. These are true somatic afferent nerves, the ganglia of which lie in the posterior spinal root ganglia. No sensory fibers pass through the superior cervical sympathetic ganglion. Note that all sensory fibers from the heart pass through the upper five thoracic sympathetic ganglia and enter the cord through the corresponding posterior spinal roots.

have more recently demonstrated that cardiac pain produced in this manner in the normal dog could be relieved only by resecting the stellate ganglion and the upper four thoracic ganglia bilaterally. Similarly, cardiac pain impulses could be completely interrupted by cutting the upper five pairs of thoracic posterior spinal roots. Aside from this concept of cardiosensory innervation, Leriche[13] insists that there also exists a sympathetic sensory innervation per se, which he terms "une sensibilité reflex," with the stellate ganglion as the center of reflex activity. He is of the opinion that impulses originating in the cardio-aortic plexus travel up these sympathetic fibers to the stellate ganglion, and in the manner of a reflex arc, effect coronary vasoconstriction through the centrifugal sympathetic motor pathways.

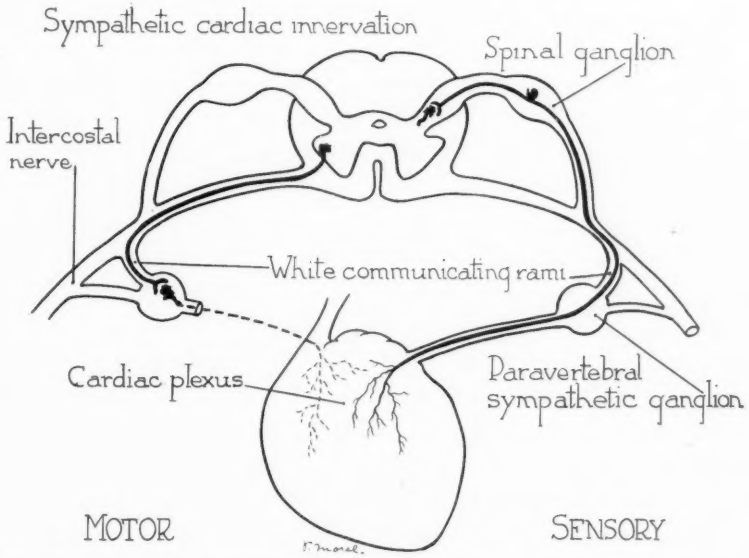


Fig. 2.—Diagrammatic representation of differences in motor and sensory cardiac innervation. On the left (motor cardiac innervation) the cell of preganglionic sympathetic fiber lies in the anterior lateral horn of the spinal cord and the neurone traverses the anterior root and the white communicating ramus to the paravertebral sympathetic ganglion where it synapses with the postganglionic cell, whose neurone courses to the cardiac plexus by way of the cardiac nerves. On the right (sensory cardiac innervation) the sensory fiber does not synapse in the sympathetic ganglion, but passes through it and the white communicating ramus to its cell in the pasterior spinal root ganglion and connects with the spinal cord by way of the posterior root.

The vasomotor efferent or accelerator impulses to the heart and coronary arteries differ from the sensory in that they travel in the true sympathetic neurones (Fig. 2). As early as 1892, Langley[14] demonstrated that accelerator impulses leave the cord by the upper five thoracic pairs of anterior roots and their white communicating rami and assumed that their transmission occurred by efferent fibers which traveled upward in the sympathetic chain to synapse in the three cervical sympathetic ganglia and send their postganglionic neurones to the heart through the cervical cardiac nerves. After resection of both cervical sympathetic

chains, including the stellate ganglia, Cannon, Lewis, and Britton[15] observed that accelerator stimuli of nervous origin still reached the heart. White, Garrey, and Atkins[12, 16] found that faradic stimulation of the second and third thoracic ganglia after division of the sympathetic trunk above this level produced as much as a 58 per cent acceleration in the heart rate. The anatomic demonstration of the existence of the thoracic cardiac nerves which form direct connection between the upper four or five thoracic ganglia and the heart by Brauecker,[9] Ionesco and Enachesco,[10] and later by Kuntz and Morehouse,[17] explain these findings (Fig. 3).

Although there is considerable controversy as regards the nervous control of coronary circulation, at the present time the preponderance of experimental evidence indicates that vasoconstrictor fibers are carried chiefly in the vagus and vasodilators in the sympathetic nerves. As a result of his investigations, Greene[18, 19] came to the conclusion that the fibers which carry vasodilator impulses emerge from the first to the sixth thoracic segment of the spinal cord, and travel upward in the chain to synapse in the stellate, the middle cervical, and superior cervical sympathetic ganglia, although the greatest number travel through the stellate ganglion. Anrep and Segall[20] showed that in dogs stimulation of the vagi causes constriction of the coronary arteries and stimulation of the sympathetics produces dilatation. The interesting studies of Kountz, Pearson, and Koenig[21] reveal that in the normally beating heart vagus stimulation slows the rate and increases coronary flow; whereas, sympathetic stimulation accelerates the heart rate and reduces the coronary flow. This seems to indicate that the cardiac nerves act directly on the caliber of the coronary arteries and coincidentally have an indirect effect on the coronary flow through changes in the muscular activity of the heart. In their opinion, this latter mechanism is more important in regulating the blood flow in the wall of the normal human heart. Some of the more recent investigations suggest that the sympathetic nerves carry both constrictor and dilator fibers. The recent investigations of Greene[22, 23] particularly support this view. As the vagus trunk is known to derive sympathetic twigs from the superior cervical ganglion, it is possible that vasoconstrictor branches emerging from the thoracic sympathetic outflow and coursing upward to the cervical sympathetic chain to synapse in the superior cervical ganglion cross to the nodose ganglion and then pass down the vagosympathetic limb to the heart. However, this concept has not been completely confirmed.

Leriche and Fontaine[24, 25] and Leriche, Herrmann, and Fontaine,[26, 27] as a result of a series of extremely interesting investigations on the blood supply of the cardiac muscles, are of the opinion that the innervation of the coronaries follows the general law of vasomotor innervation; i.e., that coronary constriction is mediated by the sympathetics. They ligated the descending branch of the left coronary artery in the dog at different

levels. Higher ligation invariably produced death from ventricular fibrillation within a few hours. However, when both stellate ganglia had been previously excised, the animal usually survived and remained in good condition. Sympathectomy seemed to increase the collateral circulation. Similar results were obtained by Cox and Robertson.[28]

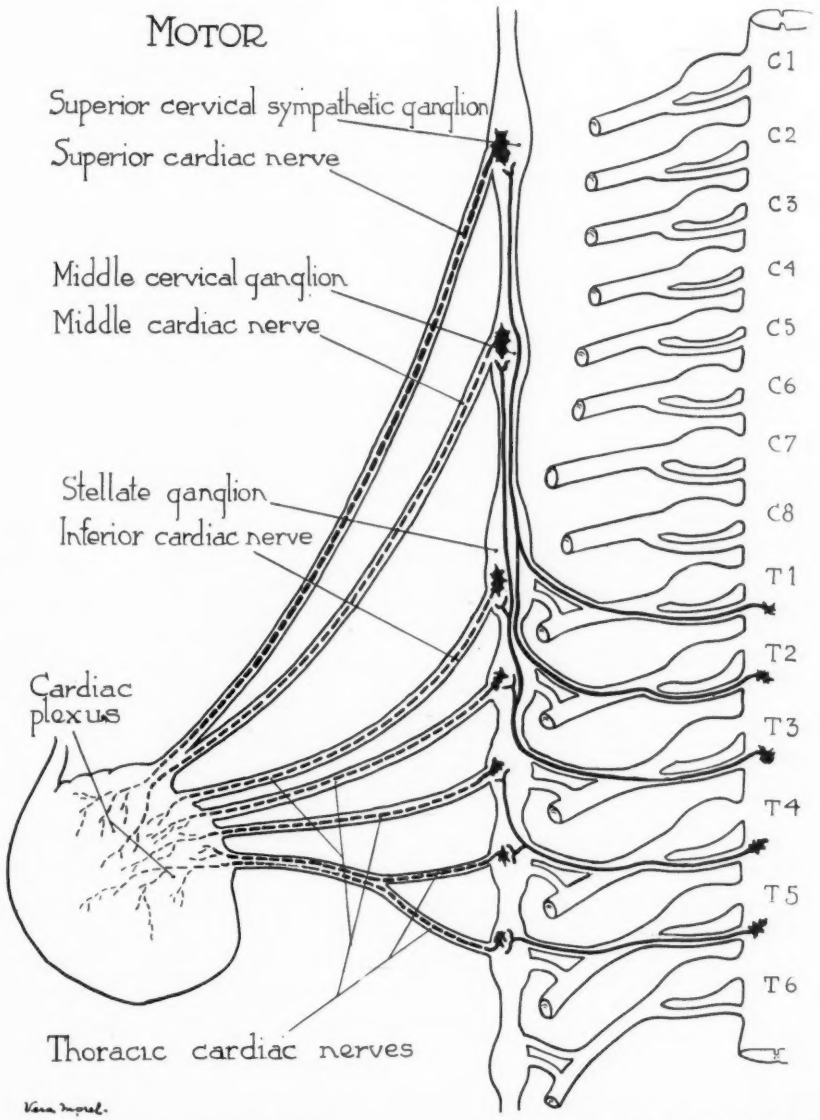


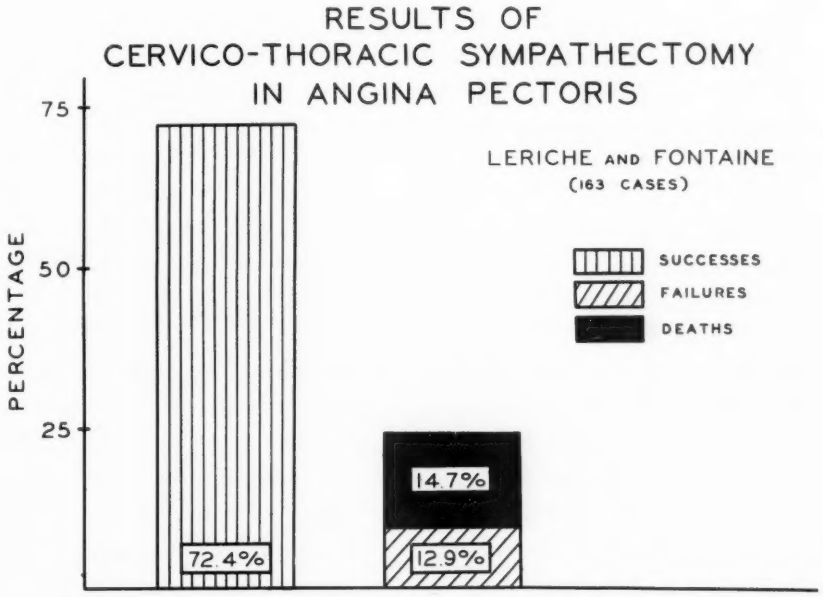
Fig. 3.—(Modified after Kuntz, Albert: Autonomic Nervous System, Philadelphia, Lea & Febiger, 1934; and White, J. C.: Autonomic Nervous System, New York, The MacMillan Company, 1935.) Diagrammatic representation of sympathetic motor innervation of heart. Presympathetic fibers course from their cells in the anterior lateral horn of the spinal cord from the first to the fifth thoracic segments through the corresponding anterior roots and the white communicating rami to reach the paravertebral sympathetic ganglia. Some make synaptic connections with the postganglionic cells in the upper four or five thoracic paravertebral ganglia; whereas, others course upward in the sympathetic chain to reach the inferior, middle, and superior cervical sympathetic ganglia. The postganglionic fibers communicate with the heart by way of the cervical and thoracic cardiac nerves.

White[29] believed this phenomenon to be not necessarily due to interruption of constrictor fibers of sympathetic origin, but rather to a paralysis of the cardiac accelerator nerves, which run through the stellate ganglia, with consequent alterations in muscle tone and diminished need for oxygen.

Most observers now believe that there is also present a tonic control of the coronary vessels, although the nature of this mechanism is still not very well understood. Some observers, such as Anrep, Hochrein, and Rein,[30] are of the opinion that this tonic constrictor action is maintained by fibers reaching the heart through the vagus nerves. On the other hand, Greene[19, 22, 23] and Hinrichsen and Ivy[31] are inclined to the view that the predominant dilator action is a function of the sympathetics passing through the stellate ganglion. A decision of this question is of more than academic importance, as has been emphasized by Danielopolu and his coworkers,[32, 33] because if the sympathetic dilators serve the important function of increasing coronary flow, then excision of the stellate ganglia for relief of angina pectoris is not only unjustifiable, but may in some instances even jeopardize the patient's life.

In 1916, Jonnesco[5] applied the procedure of sympathectomy for the first time in a case of angina pectoris. He removed the entire cervical sympathetic chain, including the stellate ganglion, bilaterally. Since then, a number of operations have been advocated on the cervical sympathetics, based upon divergent rationales with varying degrees of success. Coffey and Brown[34] advocated simplifying the procedure to extirpation of the superior cervical sympathetic ganglion, or cutting the cardiac branches of this ganglion. At the present time, Kerr[35] is one of the few surgeons who still advocates superior cervical ganglionectomy. In a recent publication, he reports complete relief of pain in 14 of 30 patients operated upon in this manner. The good results obtained by this procedure in these patients is difficult to explain in the light of recent anatomic and physiologic findings. Danielopolu[36-38] strongly condemns the removal of the stellate ganglion in any surgical procedure used in the treatment of angina pectoris, because the accelerator and dilator impulses pass through it. He suggests that the operation should consist of sectioning of the following nerves: cervical sympathetic chain, the vertebral nerve above the inferior cervical ganglion, the depressor nerve of Hofer, or any corresponding nerves present, and the nerve which springs from the cervical sympathetic chain above the superior cervical ganglion and passes to the heart. Although Leriche[39, 40] originally conformed to this view and performed section of cervical sympathetic chain above the stellate ganglion and ramisection of the stellate, more recently he[25] advocates stellate ganglionectomy. Other surgeons have either followed the procedures as advocated by the surgeons above or have modified the procedure slightly. However, in the main, the

attack has been upon the cervical sympathetic chain, including the stellate ganglion. Table I gives a summary of the results obtained by these various procedures as culled from the literature by different authors. Leriche and Fontaine's[41, 42] figures upon 172 patients selected from the literature and including their own are probably among the most representative. Of 163 cases in this group in which the results were known, 85, or 52.5 per cent, obtained good results; 33, or 20.2 per cent, showed some improvement; 21, or 12.9 per cent, showed failures; and 24, or 14.7 per cent, died. Thus, as is shown in Graph I, a little over 70 per cent will show some improvement to a greater or lesser extent. The probable explanations for these inconsistent results of cervical sympa-



Graph I.—Graphic representation of results of cervicothoracic sympathectomy in angina pectoris based upon 163 cases tabulated by Leriche and Fontaine.[41, 42]

thectomy and the fact that better results are not obtained are that these procedures only partially interrupt the sensory pathways from the heart. In the light of the recent anatomical, clinical, and experimental investigations that have been discussed above, it becomes obvious that unless the accessory pathways through the thoracic cardiac nerves are interrupted, cervical sympathectomy alone is doomed to failure in a large number of instances. Thus, it is clear that the upper thoracic ganglia, the white communicating rami, and the posterior spinal routes are the focal points through which all cardiosensory impulses must pass, and any procedure designed to interrupt these sensory impulses should logically direct the attack towards these focal points; that is, the upper four or five thoracic ganglia.

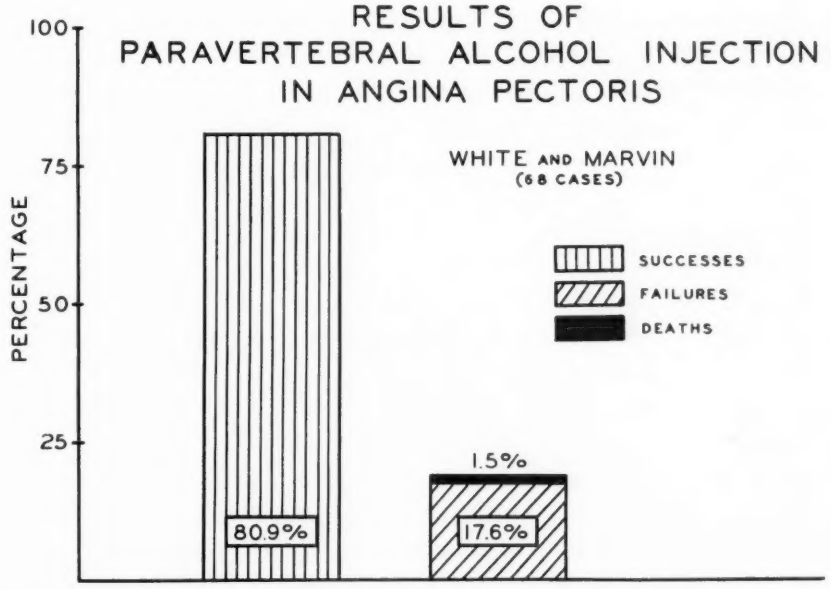
Obviously, the ideal procedure should be resection of the upper four or five thoracic sympathetic ganglia. In this way all fibers carrying sensory impulses from the heart would be interrupted. However, such a procedure in patients who are admittedly poor risks would undoubt-

TABLE I

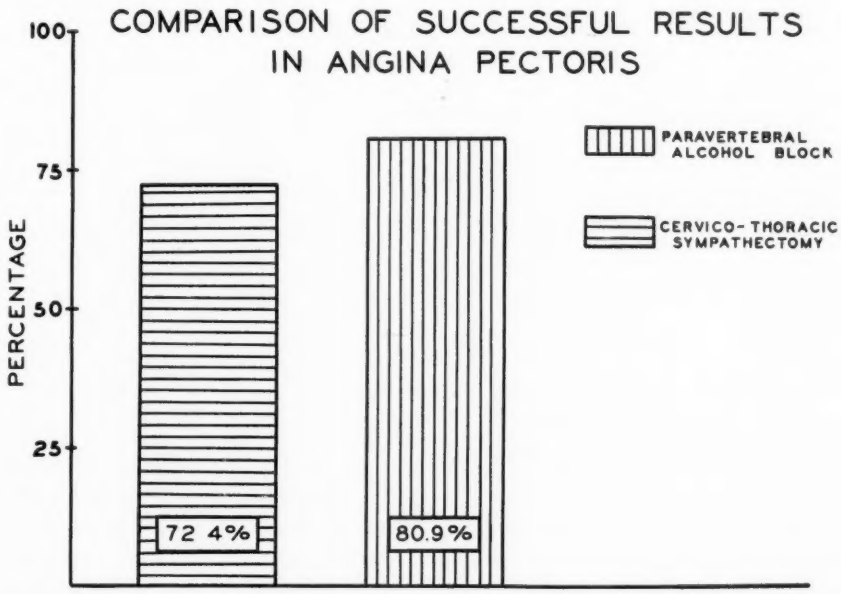
AUTHORS	NO. CASES	RESULTS: GOOD	IMPROVED	FAILURES	UNCERTAIN	MORTALITY
Reid and Andrus[118]	50	13	14	4	11	8
Cutler[119]	120	47	52	10	3	7
Fontaine[41]	94	59	11	6	5	13
Leriche and Fontaine[42]	78	26	22	15	4	11
Yater and Trewhella[120]	126	50	36	34	6	8
Orth[121]	98	52	14	9	4	19
Sarasola[122]	52	16	16	7		13

edly carry an unjustifiably high mortality. The method of Mandl,[43, 44] the paravertebral alcohol injection of the thoracic sympathetic ganglia, has been the solution of this difficulty. In this country, Swetlow[45] was the first to advocate paravertebral alcohol block for cardiac pain and to describe the technique in detail. He reported 8 cardiac patients suffering from attacks of severe precordial pain who were treated by paravertebral alcohol injections of the upper thoracic ganglia with prompt and satisfactory relief from pain in every instance. More recently, Mixter and White[46] and White[47] have perfected the technique and placed it upon a more rational basis. White[29] reports the results of paravertebral injections of alcohol for angina pectoris in 38 cases which have been followed over periods up to six years. These results are tabulated as follows: good (100 to 90 per cent relieved), 70.3 per cent; fair (90 per cent to 50 per cent relieved), 16.2 per cent; improved (50 per cent to 25 per cent relieved), 5.4 per cent; failure, 8.1 per cent; death, 1 case. The complications in this group consisted of troublesome intercostal neuritis, 3 cases; and recurrence of old bronchial asthma, 1 case. Levy and Moore[48] reported similar satisfactory results in 9 cases, and Marvin[49] in a more recent publication brought the cases of Levy up to 30. He stated that almost complete relief was obtained in approximately 40 per cent. A lesser degree of improvement was noted in another 30 per cent, and in the remaining 30 per cent the procedure was classified as a failure. Graph II illustrates the results of paravertebral alcohol injection in angina pectoris in the 68 cases reported by White and Marvin. It will be observed that successful results were obtained in 80.9 per cent of this group, failure in 17.6 per cent, and fatalities in 1.5 per cent. A comparison of these results with those of cervical thoracic sympathectomy is clearly illustrated in Graph III, and emphasizes more strongly the advantages of the former procedure. There is a higher percentage of successful results, and the mortality is

considerably lower. Another advantage is the simplicity of performance, which of course makes it a procedure attended with little or no danger, particularly in these patients who are obviously such poor risks. However, a fair critical analysis of the procedure must not fail to



Graph II.—Graphic illustration of the results of paravertebral alcohol injection based upon 38 and 30 cases reported by White[29] and Marvin,[49] respectively.



Graph III.—Graphic representation of comparison of successful results obtained in the treatment of angina pectoris by cervicothoracic sympathectomy and paravertebral alcohol block. These results are based upon the cases reported by Leriche and Fontaine[41, 42] for the former procedure and White[29] and Marvin[49] for the latter procedure.

mention a few of its disadvantages. Fortunately, these are not very significant. The effect of the alcohol is not permanent, and in some instances will necessitate reinjection. The fact that it is a procedure employing the blind injection of a destructive solution will in some cases produce certain complications. The difficulty of limiting the effect of the injected alcohol will occasionally produce a painful neuritis, and pleural injury is a constant hazard.

The technique of paravertebral alcohol injection as described by White is relatively simple. He prefers to have the patient lying on his side with the knees drawn up, the shoulder at the edge of the bed, and the head deflected forward, as in performing a spinal puncture. In our experience, it has been found more desirable to have the patient

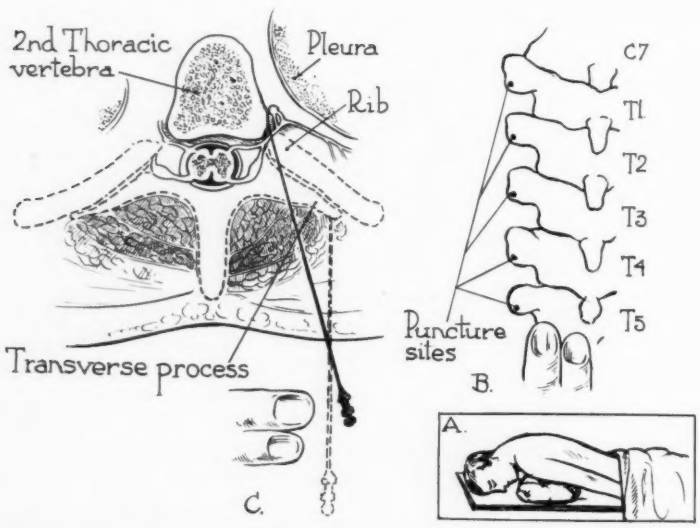


Fig. 4.—Diagrammatic representation of technique of paravertebral alcohol injection for angina pectoris. *A*, Patient lying in prone position with pillow supporting chest so as to produce hyperflexion of neck. *B*, Puncture sites are on a horizontal line approximately 2 to 2½ fingerbreadths lateral to spinous processes of the seventh cervical to fifth thoracic vertebrae, inclusive. *C*, Dotted needle indicates first position with point touching transverse process or angle of rib. Needle in solid lines indicates final correct position, which is approximately 2 fingerbreadths deeper than first position and directed medially toward midline about 20°. Point of needle is in contact with lateral aspect of body of vertebra immediately adjacent to sympathetic ganglion and chain.

lying face downward with the chest supported by pillows, as shown in Fig. 4*A*. The bony landmarks consist of the spinous processes of the seventh cervical vertebra and the first to the fifth thoracic, inclusive. In this region, the spinous processes are imbricated, and the tip of each one of these spinous processes lies at an exact horizontal level of the transverse process and the posterior angle of the rib next below, and as shown in Fig. 4*B*, the highest prominent vertebral spine, the seventh cervical, marks the level of the first rib. By means of a fine hypodermic needle an intracutaneous wheal of novocaine is formed at the points of

injection. These are made from 3½ to 4 cm. lateral to the spinous processes. This is approximately 2 to 2½ fingerbreadths (Fig. 4*B*). The points so marked lie opposite the seventh cervical and the upper three thoracic spines. Needles 8 to 10 cm. in length are then inserted at these points perpendicular to the surface of the back and at a depth varying from 3 to 3½ cm. to touch the upper four transverse processes. The needles are then inclined slightly in a caudal direction so as to slip beneath the transverse process or the angle of the rib and directed medially about 20 degrees towards the midline, and inserted for about 3 cm. or approximately 2 fingerbreadths (Fig. 4*C*). At this depth bone is usually touched, indicating that the needle is in contact with the lateral aspect of the body of the vertebra. At this stage, aspiration should always be done in order to determine whether the needles lie in a blood vessel or the subarachnoid space. Obviously if blood or spinal fluid is aspirated, then the position of the needle must be changed. When the needles have been placed in the correct position, 2 c.c. of 2 per cent novocaine adrenalin solution should be injected through each. Within a period of fifteen minutes anesthesia should appear in the axilla, a short distance down the inner surface of the arm, and over the third and fourth ribs. A well-defined Horner's syndrome and anhydrosis of the entire arm and the side of the neck and head should be present. The failure of these signs to develop indicates that the needles have not been correctly inserted, and a readjustment should be made. After it has been determined accurately that the needles have been properly placed, it is preferable to inject 3 more c.c. of novocaine through each in order to ensure widespread anesthesia and to make the final injection of alcohol painless. Three to 4 c.c. of 95 per cent alcohol is then slowly injected in each needle.

THE THYROID

Although total thyroidectomy for the relief of cardiac pain and congestive heart failure is a relatively recent advocation, the relationship between thyroid activity and cardiac disease has been implicit in the expositions of numerous authors for over a century and a half. As early as 1786, in his original and remarkably accurate description of hyperthyroidism, Parry[50] observed that angina pectoris appeared months before enlargement of the thyroid gland was apparent. At the beginning of this century, Kocher[51] in his observations upon patients in whom his father had performed total thyroidectomy reported relief of cardiac insufficiency. Hamilton[52] also noticed the beneficial effect exerted upon the cardiac insufficiency by subtotal thyroidectomy in patients with hyperthyroidism. The close relationship existing between the thyroid and the heart was strongly emphasized by Lahey and Hamilton.[53] They directed attention particularly to such "thyrocardiacs" whose cardiac

failure was so predominantly obvious that it frequently masked the underlying hyperthyroidism as the "complete relief of a complete disability" which could be obtained by thyroidectomy in these patients. Christian[54] was one of the first to appreciate the close relationship between thyroid activity and cardiac disease and, in 1925, expressed the concept that "thyroid deficiency may be . . . a form of cardiac rest, that is advantageous to the heart." Riesman[55] and Boas and Shapiro[56, 57] and others actually performed subtotal thyroidectomy in some patients having cardiac disease but not considered as having thyroid disease. However, their results were disappointing and it was not until 1933 that Blumgart, Levine, and Berlin[58] made their original proposal of total thyroidectomy in the treatment of chronic nonthyrogenous heart disease.

The rationale of total thyroidectomy in the treatment of cardiac disease is based upon two factors: (1) a decrease in tissue metabolism consequent to the removal of thyroid secretions, and (2) an interruption of cardiosensory impulses which is coincident to the operative removal of the thyroid and depends upon the anatomic relationship of the cervical cardiac nerves to the thyroid gland. In the normal individual the speed of blood flow has been shown by Blumgart and Weiss[59] to be directly dependent upon the metabolic demands of the body. It is now a well-established fact that hyperactivity of the thyroid gland results in increased tissue metabolism, and conversely, hyposecretion of the thyroid gland produces a diminished tissue metabolism. Blumgart and his coworkers[60, 61] showed that in thyrotoxicosis not associated with cardiac disease there was a commensurable increase in speed of blood flow, and conversely, in uncomplicated myxedema there was a considerable decrease in speed of blood flow. Burwell, Smith, and Neighbors[62] and Grollman[63] showed that these changes in velocity were generally in proportion to the changes in basal metabolic rate and the changes in cardiac output. However, it was observed that in cardiac insufficiency and in angina pectoris this normal relationship between speed of blood flow and metabolism no longer exists. In such instances, even though the basal metabolic rate was normal, the blood flow velocity was considerably decreased. Blumgart[64] further demonstrated that "the velocity of blood flow through the lungs parallels in general the degree of circulatory incompetence and as such provides an objective and qualitative index of the circulation." Blumgart and his associates[65, 66] further showed that this speed of blood flow in uncomplicated myxedema was frequently as slow as in congestive failure when the metabolic rate was normal and there was no evidence of circulatory failure. In other words, although these patients had a decreased speed of blood flow, their tissue metabolism was correspondingly diminished also. Thus, it seemed reasonable to assume that it would be possible to relieve a patient

in whom a diseased heart was incapable of delivering an adequate flow of blood by correspondingly diminishing the metabolic demands. This could be readily done by removing the thyroid which so influences tissue metabolism.

In angina pectoris, a similar discrepancy was also found to exist between tissue demands and blood supply.[67-72] Thus, if one considers angina pectoris as due to insufficient blood supply to the heart when there is an increased demand upon the heart in exertion and emotion although the blood supply may be adequate during rest, presumably thyroidectomy would diminish this demand so that the previous flow through the coronaries is sufficient even during strain.

The mechanism of relief of pain immediately after total thyroidectomy is still controversial. Weinstein and others[73] made postoperative studies on 50 consecutive patients and found that 20 showed early relief from pain. As a result of these studies, they were led to the conclusion that this early relief from pain was due to interruption of nerve impulses from the heart to the central nervous system and was evidently a coincidental division of cardiosensory fibers at the time of operation. The anatomical and clinical basis for this concept has been recently investigated by Weinstein and Hoff.[74] They made observations on the immediate relief of hyperesthesia and hyperalgesia of the chest during the operation and observed that in one patient immediate relief of muscle and periosteal hyperalgesia of the chest wall occurred after the severance of the inferior thyroid vessel. In the second patient immediate unilateral relief occurred after one lobe of the thyroid was shelled out of its bed. Immediate relief of hyperalgesia occurred on the left side of the chest after the second lobe of the thyroid gland was removed. In the third patient, the results of hemithyroidectomy and block of the stellate ganglion in hyperalgesia of the chest were compared. In both cases there was loss of muscle and periosteal tenderness of the chest. They also performed anatomic dissections on 10 fetuses and 6 adults, and noticed that in 70 per cent of the dissections of the thyroid lobe the superior cardiac nerve was closely applied to the posterior surface of the lobes of the thyroid. In 20 per cent of the dissections of the thyroid lobes, the middle cardiac nerves were in apposition with the posterior surface of the lobe or the inferior thyroid vessels. They concluded that this immediate relief of pain was due to injury to the superior and middle cardiac nerves and nerve plexuses on the posterior surface of the thyroid gland and its vessels. The variability in the relationship of these nerves to the posterior surface of the lobe or its vessels corresponds to the appearance of the early relief of pain following the total removal of the thyroid gland. These observations, however, do not conform with the investigations of Langley,[14] Ranson,[6] and Ionesco,[10] as well as with others who strongly deny the presence of cardiosensory

afferent fibers in the superior cardiac nerves. Recently, Heinbecker[8] has presented some evidence of cardiosensory afferent fibers in the superior cardiac nerve.

As a result of their studies on the altered sensitivity to epinephrine, Levine and his associates[75, 76] are of the opinion that the relief of pain immediately following total thyroidectomy is due to a lessened sensitivity to epinephrine. Because anginal attacks could be precipitated by the subcutaneous injection of adrenalin, they believe that in these patients there is an increased sensitivity to adrenalin. Following total thyroidectomy this adrenalin sensitivity disappeared. Shambaugh and Cutler[77, 78] produced angina pectoris in dogs by traction on the anterior descending branch of the left coronary artery. Whereas subminimal traction produced no evidence of discomfort, typical reaction to discomfort did occur after the dogs were also given intravenous injection of adrenalin. Sawyer and Brown[79] performed a group of experiments on cats whose hearts were denervated. Adrenalin was injected before and after total thyroidectomy. Their experiments demonstrated that removal of the thyroid decreases the response of the denervated heart to both injected and secreted adrenalin and that this is the result of a decreased sensitivity of the heart tissue following the removal of the thyroid. Bérard, Cutler, and Pijoan[80] recently utilized the principle that an artificially created hypoglycemia by the intravenous injection of insulin elicits a compensatory hypersecretion of adrenalin in testing the thyroid adrenal relationship in totally thyroidectomized patients. They found no material changes in arterial tension, indicating no increase in the circulatory adrenalin. Schnitker, Van Raalte, and Cutler[81] studied the relationship between the thyroid gland and the vasomotor apparatus by making skin temperature determinations on patients subjected to total thyroidectomy before and after operation. Their results showed that there was diminished vasomotor tone with relaxation of the smaller blood vessels, most pronounced shortly after removal of the thyroid gland. On the other hand, Riseman, Gilligan, and Blumgart,[82] as the result of their studies, were led to believe that there was no altered or diminished sensitivity to epinephrine following total thyroidectomy. Thus, the exact mechanism of the relief of pain immediately after operation following total thyroidectomy remains yet unsatisfactorily explained.

During the past four years, since Cutler and Schnitker[83] and Berlin[84] independently performed the first ablations of normal thyroids for heart disease, a large number of cases have been done and the results reported by numerous investigators, with a consequent better understanding of the indications, limitations, and selection of cases. The proper evaluation of any new therapeutic procedure is always difficult, because one must always rely upon the published data. Obviously, the advocates and originators of a method will be most prolific in their

writings, and their pardonable enthusiasm may unwittingly dull their critical judgment. Even a casual survey of the literature reveals distinct differences of opinion as to the value of this procedure. Such eminent surgeons as Clute,[85] Reid,[86] Trout,[87] and Moore[88] are not thoroughly convinced of the soundness and justification of the operation. Lourie[89] critically questions the rationale and believes that "the harm that will be brought about by the spread of these operations will greatly outweigh the possible temporary benefits." In order to form a fairer evaluation of the procedure, Parsons and Purks[90] tabulated data concerning all cases on whom the operation had been performed. The material was obtained from a fairly complete survey of the literature and from inquiries sent to various clinics throughout the country. Of 133 collected operations performed for angina pectoris, 71, or 55.46 per cent, showed excellent results; 36, or 28.12 per cent, were moderately improved; 5, or 3.9 per cent, were slightly improved; and 15, or 12.5 per cent, were classed as failures. The operative mortality was 3.75 per cent. These results correspond fairly closely with those reported by Weeks[91] in a somewhat similar tabulation of 100 cases in which the operation had been done in 26 clinics. If the excellent results and moderately improved groups are considered together as satisfactory, it will be observed that 83.58 per cent showed good results in the series reported by Parsons and Purks,[90] and 91.4 per cent in those collected by Weeks.[91] Thus, these statistics indicate that it is undeniably a distinctly valuable procedure in relieving cardiac pain. Whether the procedure prolongs life or not cannot be answered. It is admittedly a procedure attempting to relieve symptoms and not to affect cardiac pathology.

There are certain disadvantages of the procedure that must be considered in its proper evaluation. Total ablation of the thyroid is difficult in any type of case, and in these patients who are admittedly poor risks it will carry a very definite mortality. There will also be a fairly high incidence of complications. In the collected series reported by Parsons and Purks,[90] recurrent laryngeal injury occurred in 8.6 per cent and tetany in 10.3 per cent of the cases. Fortunately, this latter complication was of serious consequence in only one instance. It must be remembered, however, that these complications have occurred in the hands of surgeons who possess a relatively wide experience with thyroid surgery.

Another disadvantage of the procedure is the production of myxedema, as it is, in truth, the substitution of one disease for another. However, the conversion of a previously alert and active patient into the sluggish state associated with myxedema may be justified if it relieves the patient of agonizing and intractable pain. Although the undesirable consequences of artificially induced myxedema can be alleviated to some extent by the proper administration of thyroxin, in many

instances it may be extremely difficult to find the optimum dosage. It must be remembered that, whereas thyroxin counteracts these effects of myxedema, in order to obtain the full benefit of the operation these individuals must be kept at a low basal metabolic rate. Hurzthal[92] wisely calls attention to this consideration. Adequate doses of thyroxin to obviate the effects of myxedema may cause the patient to suffer from angina, and a reduction of thyroxin to relieve the angina may cause the ill effects of myxedema.

Unquestionably, the procedure has been inadvisedly performed in many instances, but with increasing experience the criteria for the selection of patients have become more rigid. Blumgart[93] advises against the operation in the presence of rapidly progressive cardiovascular disease, such as malignant hypertension or syphilitic cardiovascular disease. He agrees with Hepburn[94] and Levine and others[95] that it is also unwise to operate upon patients who are in the terminal stages of the diseases. Another contraindication to operation is a low preoperative basal metabolic rate. Mixter, Blumgart, and Berlin[96] hesitate to operate upon those patients in whom the preoperative basal metabolic rate is below 15 per cent and consider a basal metabolic rate of 20 per cent or more a definite contraindication to operation. The presence of a recent coronary occlusion, renal insufficiency, active infection, such as bronchiectasis, lung abscess, and active rheumatic involvement, are further contraindications to operation. Wolferth[97] is of the opinion that the operation should not be performed in patients who do not respond to medical therapy.

Although no attempts will be made here to give a detailed technical discussion of total extirpation of the normal thyroid gland, there are certain aspects of the technique which demand consideration. The procedure is not one that can be undertaken lightly and should never be performed by one who is not thoroughly familiar with the normal anatomy of the thyroid gland and its relationship to the surrounding structures as well as with the variations which may occur.

The type of anesthetic employed is of considerable importance as has been emphasized by Mixter and others,[96] Berlin,[98] Cutler and coworkers,[99] and others. These surgeons who have had considerable experience with the procedure insist upon the use of local analgesia. Although they employed general anesthesia in their earlier cases, they found that it proved far less satisfactory as it abolished the cough reflex and thus increased the danger of pulmonary complications. However, Murtagh[100] still prefers general anesthesia because it obviates mental anxiety and avoids the use of adrenalin which may induce an attack of angina. Cutler and others[99] also consider local analgesia more desirable because it permits easier determination of injury to the recurrent laryngeal nerve during the operation. Avoidance of injury to recurrent laryngeal nerves and of the parathyroid glands necessitates

extreme care in dissection. The latter authors[99] advise removing each lobe of the thyroid by working from that side of the patient because of the fact that in their first few cases they injured two left recurrent nerves while doing the procedure according to their previous custom of operating entirely from the right side. We[101] have also made a similar observation and consider this a valuable suggestion. Berlin[102] has called attention to the variations in the anatomic relationship of the recurrent laryngeal nerve. The fact that, in 10 per cent of the cases he studied, the recurrent laryngeal nerves partially penetrated the gland substance emphasizes the care that must be taken to visualize the nerve in order to avoid its injury while freeing the gland. Freedman[103] advocates direct laryngoscopy after the removal of one lobe in order to determine whether a vocal cord has been paralyzed. In order to more readily mobilize the lateral lobes, Berlin[84] advocates the transverse division of the infrahyoid group of muscles.

In order to diminish the surgical hazards of total thyroidectomy, some investigators have attempted to permanently lower the metabolic rate by less drastic means. Heavy doses of roentgen irradiation were employed by Friedman and Blumgart[104] in some patients but were without benefit and the method was abandoned. More recently, Lyon and Horgen[105] and Friedman[106] have advocated a less radical surgical procedure. They have performed and recommend ligation and division of the superior and inferior thyroid arteries. The former authors believe that this not only decreases the amount of blood entering the thyroid, but also cuts off all stimuli from the sympathetic nervous system to the gland. This procedure is sharply criticized by Blumgart[93] as not being a reliable substitute for total thyroidectomy, because the blood supply to the thyroid gland is derived, to an important degree, from many vessels penetrating the posterior part. He quotes the investigations of Fine and Levenson,[107] who, after removing the entire thyroid gland of rabbits and then replacing the gland immediately in its former position, were unable to find any changes in the metabolic rate in approximately 50 per cent of their animals. He believes that similar difficulties apply to complete separation of the thyroid gland from the autonomic nervous system.

COLLATERAL BLOOD SUPPLY

An entirely new principle in the surgical treatment of coronary thrombosis has been devised and advocated by Claude S. Beck.[108, 109] This method consists of an attempt to develop a collateral circulation by the production of a new blood supply to the heart by grafting tissues into the myocardium (Fig. 5). The rationale of this procedure is based upon the attempt to correct the decreased myocardial vascularity which invariably occurs with coronary sclerosis. It is a well-known fact that the compensatory circulatory mechanisms of the heart are dreadfully

inadequate. This is due to the peculiar anatomic arrangement of the vascular supply of the myocardium. The myocardium has only two coronary arteries. When one of these arteries becomes occluded, compensatory adjustments are made either through the other artery, by way of the thebesian channels, or through the anastomoses with the aorta which exist in the fat at the base of the heart. Such compensatory mechanisms are obviously inadequate as attested by the fearful mortality in coronary disease. Thus, it becomes apparent that the addition of other anastomotic channels to the heart might change the previously inadequate compensatory mechanism to one that is adequate. It was with such reasoning that Beck[110] began his experiments in February, 1932.

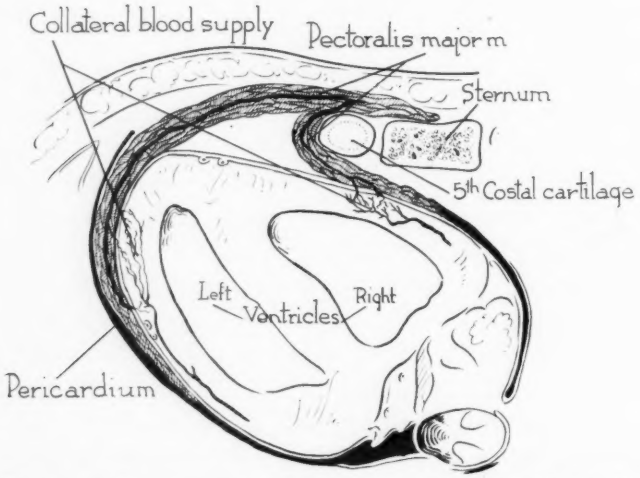


Fig. 5.—Diagrammatic representation of method of increasing collateral blood supply to the heart according to Beck's procedure. The pectoral muscle is used as a pedicle graft with one portion of it attached to the right ventricle and another portion to the left ventricle.

Although this investigator fully appreciated the Herculean task confronting him, there were two facts which suggested the feasibility of this procedure. Hudson and others[111] demonstrated the presence of blood vessels in the fat at the base of the heart anastomosing the coronary system with branches of the aorta; and Moritz, Hudson, and Orgain[112] established the existence of blood vessels in pericardial adhesions. Further experimentation was then necessary in order to determine: (1) whether it was possible to deliberately produce these anastomotic channels, and (2) whether they could serve a functional purpose.

Beck[113] and his coworkers first produced a collateral vascular bed by destroying the mesothelial envelope around the heart by roughening the lining of the parietal pericardium and the epicardium. Various tissues, such as fibrous pericardium, pericardial fat, pedicle grafts of pectoral muscle, and omentum, were used for the new vascular bed and within

three weeks anastomoses between the grafts and the heart could be demonstrated. These anastomoses were demonstrated[114] by the presence in the myocardium of a dye previously introduced by way of the graft and also by injecting a solution of barium sulphate[115] into a coronary artery and tracing the location of the solution in the chest by roentgenograms.

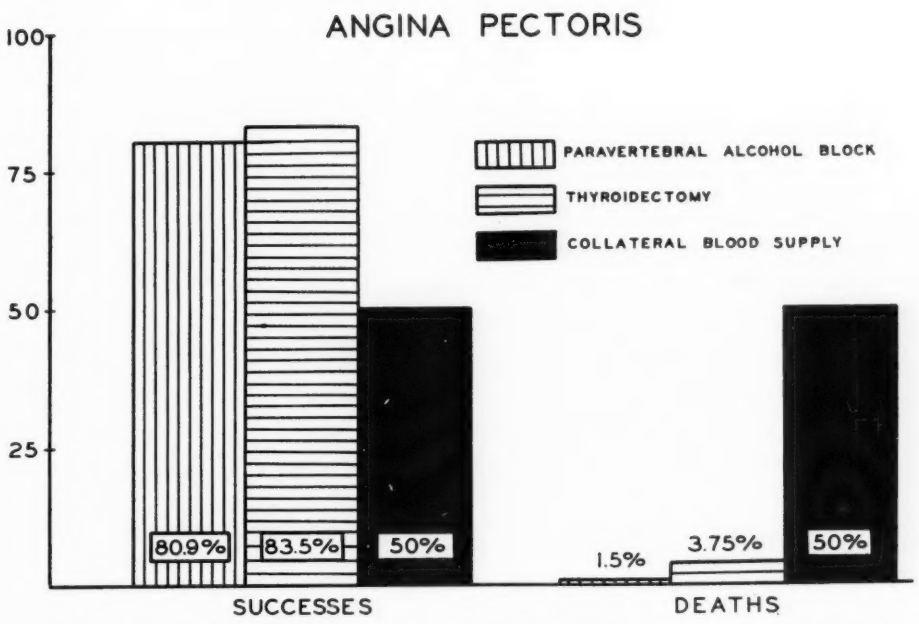
In another interesting group of experiments it was found that the vascular graft could act as a protective measure against sudden complete occlusion of one of the coronary arteries.[110] Of ten normal dogs in which the coronary artery was ligated, 7, or 70 per cent, died within a very short time. In 12 dogs in which a collateral vascular bed had been previously developed, ligation of the coronary artery produced death in only 4, or 33.3 per cent. In another group of experiments it was found that after giving the heart a collateral vascular bed it was possible to completely occlude the right and both major branches of the left coronary artery by doing the occlusion in four or five stages. In this manner the only blood supply to the myocardium from the coronary was from the small septal branch which comes off above the bifurcation of the left main stem. In another group of experiments, Beck and his coworkers showed the importance of an equal distribution of blood to the myocardium. If the right and both major branches of the left coronary arteries were occluded to about one-third of their cross-section in one stage, the animals would recover. On the other hand, if the four or five peripheral branches of the coronary artery over the apex of the left ventricle were completely ligated in one stage, ventricular fibrillation always developed. It can be readily observed that the total coronary blood flow in the former group of experiments is considerably less than in the latter, yet it was in the latter group that a fatal termination always occurred. Beck and his collaborators believe that the significance of these experiments is the extreme importance of the maintenance of uniform distribution of blood flow. These investigators believe that a collateral vascular bed effects an equal distribution of blood to the myocardium by transporting blood from extracardiac sources into the myocardium and from one part of the heart where the circulation is good to another part of the heart where the circulation is deficient.

Emboldened by these propitious experimental investigations, Beck and his collaborators[115] attempted their application in cases with coronary sclerosis, and it was done in collaboration with their cardiologist, Dr. Harold Feil. The operation was performed for the first time on a patient with coronary sclerosis on February 13, 1935. This patient was a white male laborer, twenty-eight years of age, who had typical substernal pain of two years' duration and was finally forced to give up his work. The patient made an excellent recovery from the operation and

for the past year has been employed as a gardener, doing the work of a man in good health. He has no pain and takes no drugs.

In his most recent communication, Beck[116] states that he has performed the operation upon 16 patients, with a mortality of 50 per cent. This is undeniably a frightfully high mortality and may appear almost unwarranted. However, in justification, the author states that this was an extremely bad group of patients with advanced stages of coronary sclerosis. They were patients who had previously concluded that there was nothing to risk because life without improvement was not worthwhile. However, the author feels that this mortality must necessarily be reduced in order to make the operation practical. He is of the opinion that this can be accomplished; first, by a careful selection of patients who do not have a too far advanced coronary sclerosis, and second, by reducing the magnitude of the operation. The latter factor, he believes, has already been accomplished to some extent, as is discussed below in a consideration of the technique. In the last 5 patients in whom this was done, there were no operative deaths. In his concluding remarks, the author opines that in general the results seem sufficiently good to encourage further development of the subject. He considers this procedure a direct attack upon the coronary sclerosis with the purpose of giving the myocardium additional blood supply, and thus preserving the heart function. Its concern with angina pectoris is only secondary. However, in those patients who survived there was complete relief of pain in several, and in the remaining there was marked relief of pain. There was also an apparent increase in the functional capacity of the heart.

The technical procedure consists of grafting part of the pectoral muscle upon the myocardium. The skin incision is made transversely over the precordium, and the pectoral muscles are separated from the chest wall by blunt dissection. Whereas originally Beck employed a bilateral approach to the heart by the removal of two costal cartilages on each side of the sternum, he has since simplified it and utilizes a unilateral approach. The pectoral muscle is transected laterally about four inches from the sternum to make a graft with the pedicle attached along the sternal margin. The fifth and sixth costal cartilages are removed, care being taken to avoid injury to the mammary vessels, and the parietal pericardium is opened. By means of a burr the lining of the parietal pericardium and epicardium is roughened. The author states that they have attempted to avoid such trauma to the epicardium because it initiates extrasystole, and refers to the observations of Mautz,[117] who found that the application of cocaine directly to the surface of the heart will block these impulses. He states also that in several of the patients powdered beef bone was placed in the pericardial cavity for the purpose of producing a low grade foreign body reaction. The muscle graft is



Graph IV.—Comparison of the results obtained by three methods of treatment in coronary artery disease and cardiac pain. The figures on paravertebral alcohol block are based upon 68 cases reported by White[29] and Marvin[49]; those on thyroidectomy are the results obtained in a series collected by Parsons and Purks,[90] and the results on collateral blood supply were reported by Beck.[116]

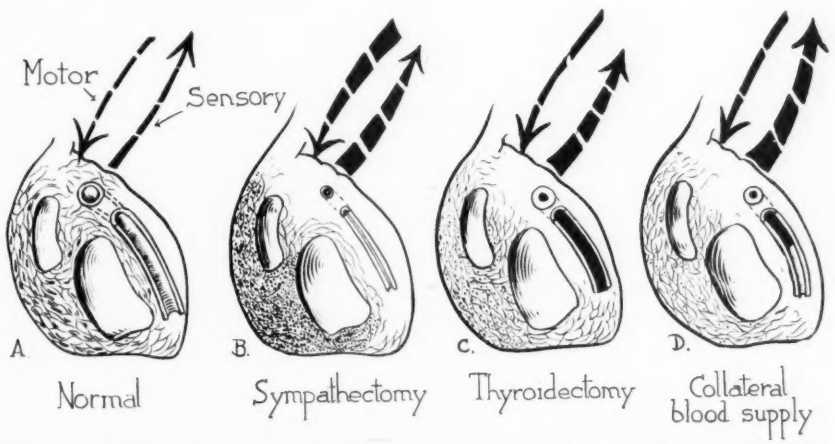


Fig. 6.—Diagrammatic representation of therapeutic procedures indicated in various types of coronary disease. *A* represents a normal heart with normal musculature and vascular supply. The thickness of the arrows represents normal degrees of motor and of sensory cardiac innervation. *B* represents the type of case in which a therapeutic attack upon the sympathetic nervous system is indicated: (1) cases in which there is increased cardiosensory and motor sympathetic innervation which is associated with vasoconstriction and considerable pain; (2) cases in which there is marked fibrosclerotic myocardial changes indicative of advanced cardiac disease which contraindicates more formidable procedures. *C* represents type of cardiac lesion in which thyroidectomy is indicated. There is some fibrosis of the cardiac musculature and occlusion of coronaries, which is due to thrombosis rather than to vasoconstriction. These patients have an angina of effort rather than emotion as in *B*. There is also an increase in the cardiosensory innervation. *D* represents the type of case in which collateral blood supply is indicated. The cardiac musculature is little involved, and the thrombosis and occlusion of the coronaries are not extensive.

divided into two parts by incising parallel with its fibers along the lower margin of the third rib, and the upper part of the graft is placed beneath the sternum to the right ventricle, while the lower is applied to the left ventricle. The pericardial cavity is then left widely open so that the adjacent vascularized tissues are in contact with the anterior aspect of the heart.

The three main methods of attack in the surgical treatment of coronary artery disease and cardiac pain have been considered and discussed. Obviously, the enthusiastic advocates of each method will paint a glowing picture of the advantages of their method and will have a pardonable tendency to dim their disadvantages. Thus, a proper evaluation may be extremely difficult. Probably each method has its appropriate place in the treatment of this important disorder, and a critical analysis may aid us in determining which type of patient is best suited for each method.

If an attempt be made to compare the advantages and disadvantages of the three methods from the standpoint of successful results and mortality, the graphic illustration (Graph IV) reveals that thyroidectomy has a slight advantage over paravertebral alcohol block and that both have a marked advantage over collateral blood supply. On the other hand, the mortality from paravertebral alcohol block is practically negligible with thyroidectomy having a mortality two and a half times as high. The mortality of 50 per cent in the collateral blood supply method makes it undeniably a formidable procedure.

Because these three surgical methods of attack have different rational bases and because coronary artery disease and cardiac pain vary in their pathologic physiologies, it may be possible to indicate in which type of patient each method may be most suitable. We have attempted to illustrate this diagrammatically (Fig. 6). Fig. 6 *A* represents a normal heart with normal musculature and vascular supply. The thickness of the arrows represents normal degrees of motor and of sensory cardiac innervation. In comparison to this, Fig. 6 *B* represents the type of case in which a therapeutic attack upon the sympathetic nervous system is indicated: (1) cases in which there is increased cardiosensory and motor sympathetic innervation which is associated with vasoconstriction and considerable pain; (2) cases in which there is marked fibrosclerotic myocardial change indicative of advanced cardiac disease which contraindicates more formidable procedures. Fig. 6 *C* represents type of cardiac lesion in which thyroidectomy is indicated. There is some fibrosis of the cardiac musculature and occlusion of coronaries, which is due to thrombosis rather than to vasoconstriction. These patients have an angina of effort rather than emotion as in *B*. There is also an increase in the cardiosensory innervation. The patients who are probably best

suited for the collateral blood supply method are represented in Fig. 6 *D*. The cardiac musculature is little involved, and the thrombosis and occlusion of the coronaries are not extensive.

REFERENCES

1. Heberden, W.: Some Account of a Disorder of the Breast, Med. Tr. College Phys. **2**: 59, 1786.
2. Herrick, J. B.: Clinical Features of Sudden Obstruction of the Coronary Arteries, J. A. M. A. **59**: 2015, 1912.
3. Smith, Harry L.: Incidence of Coronary Sclerosis Among Physicians as Compared With Members of Other Occupations, J. A. M. A. **108**: 1327, 1937.
4. Franck, Francois: Signification physiologique de la résection du sympathique dans la maladie de Basedow, l'épilepsie, l'iodiotie, et le glaucoma, Bull. Acad. de méd. **41**: 565, 1899.
5. Jonnesco, T.: Traitement chirurgical de l'angine de poitrine par la résection du sympathique cervico-thoracique, Bull. Acad. de méd. **84**: 93, 1920.
6. Ranson, S. W., and Billingsley, P. R.: The Superior Cervical Sympathetic Ganglion and Cervical Portion of Sympathetic Trunk, J. Comp. Neurol. **29**: 313, 1918.
7. Stöhr, P., Jr.: Mikroscopische Anatomie des vegetativen Nervensystems, Berlin, 1928, Julius Springer.
8. Heinbecker, P.: Anatomic and Physiologic Criteria for Surgical Relief of Cardiac Pain, J. Thoracic Surg. **2**: 517, 1932-33.
9. Brauecker, W.: Der Brustteil des vegetativen Nervensystems und seine klinisch-chirurgische Bedeutung, Beitr. z. klin. Tuberk. **66**: 1, 1927.
10. Ionesco, D., and Enachesco, M.: Nerfs cardiaques maissant de la chaîne thoracique du sympathique, au-dessous du ganglion stellaire. Les nerfs cardiaques thoraciques chez quelques mammifères, Compt. rend. Soc. de Biol. **97**: 977, 1927.
11. Sutton, D. C., and Lueth, H. C.: Pain: Experimental Production of Pain on Excitation of the Heart and Great Vessels, Arch. Int. Med. **45**: 827, 1930.
12. White, J. C., Atkins, J. A., and Garrey, W. E.: Cardiac Innervation. Experimental and Clinical Studies, Arch. Surg. **26**: 765, 1933.
13. Leriche, R.: La Chirurgie de la Douleur, Paris, 1937, Masson & Cie.
14. Langley, J. N.: On the Origin From the Spinal Cord of the Cervical and Upper Thoracic Sympathetic Fibers With Some Observations on White and Grey Rami Communicantes, Phil. Tr. Lond. **183**: 85, 1892.
15. Cannon, W. B., Lewis, J. T., and Britton, S. W.: Studies on the Conditions of Activity in Endocrine Glands: XVII. A Lasting Preparation of the Denervated Heart for Detecting Internal Secretion With Evidence for Accessory Accelerator Fibers From the Thoracic Sympathetic Chain, Am. J. Physiol. **77**: 326, 1926.
16. White, J. C.: Experimental and Clinical Studies in the Surgical Treatment of Angina Pectoris, Ann. Int. Med. **7**: 229, 1933.
17. Kuntz, A., and Morehouse, A.: Thoracic Sympathetic Cardiac Nerves in Man. Their Relation to Cervical Sympathetic Ganglionectomy, Arch. Surg. **20**: 607, 1930.
18. Greene, C. W.: An Analysis of the Efferent Pathways and Vasomotor Control of the Coronary Circulation of the Dog, Am. J. Physiol. **97**: 526, 1931.
19. Idem: The Nerve Control of the Coronary Vessels With New Experimental Evidence for the Pathways of Efferent Constrictor and Dilator Neurones in the Dog, Am. J. Physiol. **113**: 361, 1935.
20. Anrep, S. V., and Segall, H. N.: The Regulation of the Coronary Circulation, Heart **13**: 239, 1926.
21. Kountz, W. B., Pearson, E. F., and Koenig, K. F.: Observations on the Effect of Vagus and Sympathetic Stimulation on the Coronary Flow of the Revived Human Heart, J. Clin. Investigation **13**: 1065, 1934.
22. Greene, C. W.: Control of the Coronary Blood Flow by Reflexes Arising in Widely Distributed Regions of the Body, Am. J. Physiol. **113**: 399, 1935.
23. Idem: An Analysis of the Relation of the Coronary Constrictor and Dilator Nerves in the Cervical Vaso-Sympathetic of the Dog, Am. Heart J. **11**: 592, 1936.

24. Leriche, R., and Fontaine, R.: Chirurgie du sympathique, Rev. Neurol. **1**: 1046, 1929.
25. Idem: Chirurgie des nerfs du coeur. Rapport XLI. Congrés françois de chirurgie, Paris, 1932.
26. Leriche, R., Herrmann, L., and Fontaine, R.: Ligature de la coronaire gauche et fonction cardiaque chez l'animal intact, Compt. rend. Soc. de Biol. **107**: 545, 1931.
27. Idem: Ligature de la coronaire gauche et fonction du coeur après énervation sympathique, Compt. rend. Soc. de Biol. **107**: 547, 1931.
28. Cox, W. V., and Robertson, H. F.: Effect of Stellate Ganglionectomy on Cardiac Function of Intact Dogs, and Its Effect on Extent of Myocardial Infarction and on Cardiac Function Following Coronary Artery Occlusion, Am. Heart J. **12**: 285, 1936.
29. White, J. C.: The Autonomic Nervous System, New York, 1935, The Macmillan Company.
30. Anrep, Hochrein, and Rein: Quoted by Wiggers, Carl J.: The Physiology of Cardiac Pain, in Robert L. Levy's Diseases of the Coronary Arteries and Cardiac Pain, New York, 1936, The Macmillan Company, Chapter VI.
31. Hinrichsen, J., and Ivy, A. C.: Effect of Stimulation of Visceral Nerves on Coronary Flow in Dogs, Arch. Int. Med. **51**: 932, 1933.
32. Danielopolu, D., and Marcou, I.: Nouvelles recherche sur les vaso-moteurs coronariens. Considerations sur les échecs et les accidents de la stellectomie dans l'angine de poitrine, J. de physiol. et de path. gén. **31**: 33, 1933.
33. Danielopolu, D., Marcou, I., and Proca, G. G.: Sur l'innervation des coronaires. Rôle des filets sympathiques et des filets parasympathiques, Compt. rend. Soc. de Biol. **107**: 419, 1931.
34. Coffey, W. B., and Brown, P. K.: The Surgical Treatment of Angina Pectoris, Arch. Int. Med. **31**: 200, 1923.
35. Kerr, H. Hyland: The Results of Superior Cervical Sympathectomy in Angina Pectoris, South. Surgeon **5**: 365, 1936.
36. Danielopolu, D.: The Pathology and Treatment of Angina Pectoris, Brit. M. J. **2**: 553, 1924.
37. Idem: The Surgical Treatment of Angina Pectoris, Brit. M. J. **1**: 180, 1926.
38. Idem: The Present Stage of the Surgical Treatment of Angina Pectoris. Results in 28 Cases, Treated by the Method of Suppressing the Pressor Reflex, Presse méd. **38**: 1789, 1930.
39. Leriche, R., and Fontaine, R.: The Surgical Treatment of Angina Pectoris, Am. Heart J. **3**: 649, 1928.
40. Leriche, R.: Surgical Treatment of Angina Pectoris, Gaz. d. hôp .**104**: 517, 1931.
41. Fontaine, R.: Les résultats actuels du traitement chirurgical de l'angine de poitrine, Thèse de Strasbourg, 1925.
42. Leriche, R., and Fontaine, R.: The Present Results of Surgical Treatment of Angina Pectoris, J. de chir. **38**: 785, 1931.
43. Mandl, F.: Weitere Erfahrungen mit der paravertebralen Injektion bei der Angina Pectoris, Wien. klin. Wchnschr. **38**: 759, 1925.
44. Mandl, F.: Surgery of Vegetative Pain (Angina Pectoris, Endarteritis, etc.), Wien. klin. Wchnschr. **49**: 531, 1936.
45. Swetlow, G. I.: Paravertebral Alcohol Block in Cardiac Pain, Am. Heart J. **1**: 393, 1925-26.
46. Mixter, W. J., and White, J. C.: Alcohol Injection in Angina Pectoris, Ann. Surg. **89**: 199, 1929.
47. White, J. C.: Painful Aneurysms of the Aortic Arch. Relief by Paravertebral Injections of Procaine and Alcohol, J. A. M. A. **99**: 10, 1932.
48. Levy, R. L., and Moore, R. L.: Paravertebral Injections of Alcohol for the Relief of Cardiac Pain: A Review of Experience to Date and a Report of 9 Cases, Arch. Int. Med. **48**: 146, 1931.
49. Marvin, H. M.: An Evaluation of the Surgical Treatment of Angina Pectoris, Bull. New York Acad. Med. **11**: 453, 1935.
50. Parry, C. H.: Collections From the Unpublished Medical Writings of the Late Caleb Hillier Parry, London, Underwood **2**: 478, 1852.
51. Kocher, A.: Ueber Morbus Basedowi, Mitt. a. d. Grenzgeb. d. Med. u. Chir. **1**: 1, 1902.

52. Hamilton, B. E.: Clinical Notes on Hearts in Hyperthyroidism, Boston M. & S. J. **186**: 216, 1922.
53. Lahey, F. H., and Hamilton, B. E.: Thyrocardiacs: Their Diagnostic Difficulties: Their Surgical Treatment, Surg., Gynec. & Obst. **39**: 10, 1924.
54. Christian, Henry A.: Heart and Its Management in Myxedema, Rhode Island M. J. **8**: 109, 1925.
55. Riesman, D.: Hypertension in Women, J. A. M. A. **73**: 330 ,1919.
56. Boas, E. P., and Shapiro, S.: Diastolic Hypertension With Increased Basal Metabolic Rate, J. A. M. A. **84**: 1558, 1925.
57. Boas, E. P., and Shapiro, S.: Further Observations on Patients With Hypertension and Increased Basal Metabolic Rate, Am. Heart J. **1**: 643, 1925-26.
58. Blumgart, H. L., Levine, S. A., and Berlin, D. D.: Congestive Heart Failure and Angina Pectoris. The Therapeutic Effect of Thyroidectomy on Patients Without Clinical or Pathologic Evidence of Thyroid Activity, Arch. Int. Med. **51**: 866, 1933.
59. Blumgart, H. L., and Weiss, S.: Studies on the Velocity of Blood Flow. II. The Velocity of Blood Flow in Normal Resting Individuals and a Critique of the Method Used, J. Clin. Investigation **4**: 15, 1927; idem: VII. The Pulmonary Circulation Time in Normal Resting Individuals, J. Clin. Investigation **4**: 399, 1927.
60. Blumgart, H. L., Berlin, D. D., Davis, D., Riseman, J. E. F., and Weinstein, A. A.: Total Ablation of Thyroid in Angina Pectoris and Congestive Failure. XI. Summary of Results in Treating 75 Patients During the Last 18 Months, J. A. M. A. **104**: 17, 1935.
61. Blumgart, H. L., Gargill, S. L., and Gilligan, D. R.: Studies on the Velocity of Blood Flow. XIII. The Circulation Response to Thyrotoxicosis, J. Clin. Investigation **9**: 69, 1930.
62. Burwell, C. S., Smith, W. C., and Neighbors, D. W.: The Output of the Heart in Thyrotoxicosis With the Report of a Case of Thyrotoxicosis Combined With Primary Pernicious Anemia, Am. J. Med. Sc. **178**: 157, 1929.
63. Grollman, A.: The Cardiac Output of Man in Health and Disease, London, 1932, Buillière, Tindall, and Cox.
64. Blumgart, H. L.: The Velocity of Blood Flow in Health and Disease. The Velocity of Blood Flow in Man and Its Relation to Other Measurements of the Circulation, Medicine **10**: 1, 1931.
65. Blumgart, H. L., Gargill, S. L., and Gilligan, D. R.: Studies on the Velocity of Blood Flow. XIV. The Circulation in Myxedema With a Comparison of the Velocity of Blood Flow in Myxedema and Thyrotoxicosis, J. Clin. Investigation **9**: 91, 1930.
66. Blumgart, H. L., and Weiss, S.: Clinical Studies on the Velocity of Blood Flow. IX. The Pulmonary Circulation Time, the Velocity of Venous Flow to the Heart, and Related Aspects of the Circulation in Patients With Cardiovascular Disease, J. Clin. Investigation **5**: 343, 1928.
67. Katz, L. N., Hamburger, W. W., and Lev, M. W.: The Diagnostic Value of Epinephrine in Angina Pectoris, Am. Heart J. **7**: 371, 1931-32.
68. Lev, M. W., and Hamburger, W. W.: Association of Angina Pectoris and Hyperthyroidism, Am. Heart J. **3**: 672, 1927-28.
69. Lev, M. W., and Hamburger, W. W.: Studies in Thyroid Disease. II. Angina Pectoris and Hyperthyroidism, Am. Heart J. **8**: 109, 1932-33.
70. Means, J .H.: An Address on Certain Aspects of Pathogenesis of Angina Pectoris, Canad. M. A. J. **24**: 193, 1931.
71. Idem: Hypothyroid Heart Disease, New England J. Med. **208**: 541, 1933.
72. Idem: The Heart and the Surgeon, Ann. Int. Med. **7**: 131, 1933-34.
73. Weinstein, A. A., Davis, D., Berlin, D. D., and Blumgart, H. L.: The Mechanism of the Early Relief of Pain in Patients With Angina Pectoris and Congestive Failure After Total Ablation of the Normal Thyroid Gland, Am. J. M. Sc. **187**: 753, 1934.
74. Weinstein, A. A., and Hoff, H. E.: Mechanism of Relief of Pain Immediately After Total Thyroidectomy for Angina Pectoris and Congestive Failure, Surg., Gynec. & Obst. **64**: 165, 1937.
75. Eppinger, E. C., and Levine, S. A.: The Effect of Total Thyroidectomy on the Response to Adrenalin, Proc. Soc. Exper. Biol. & Med. **31**: 485, 1934.
76. Levine, S. A., Ernstene, A. C., and Jacobsen, B. M.: Use of Epinephrine as a Diagnostic Test for Angina Pectoris, With Observations on the Electrocardiographic Changes Following Injections of Epinephrine Into Normal Patients and Into Patients With Angina Pectoris, Arch. Int. Med. **45**: 191, 1930.

77. Shambaugh, P.: Experimental Angina Pectoris in the Dog, With Particular Reference to the Effect of Total Thyroidectomy, Proc. Soc. Exper. Biol. & Med. **31**: 978, 1934.

78. Shambaugh, P., and Cutler, E. C.: Total Thyroidectomy in Angina Pectoris. An Experimental Study, Am. Heart J. **10**: 221, 1934-35.

79. Sawyer, M. E. M., and Brown, M. G.: The Effect of Thyroidectomy and Thyroxine on the Response of the Denervated Heart to Injected and Secreted Adrenine, Am. J. Physiol. **110**: 620, 1935.

80. Bérard, M., Cutler, E. C., and Pijoan, M.: Un test de l'action de la thyroïdectomie totale dans l'angine de poitrine, Presse méd. **44**: 1307, 1936.

81. Schnitker, M. T., Van Raalte, L. H., and Cutler, E. C.: Effect of Total Thyroidectomy in Man, Arch. Int. Med. **57**: 857, 1936.

82. Riseman, J. E. F., Gilligan, D. R., and Blumgart, H. L.: Treatment of Congestive Heart Failure and Angina Pectoris by Total Ablation of the Normal Thyroid Gland. XVI. The Sensitivity of Man to Epinephrine Injected Intravenously Before and After Total Thyroidectomy, Arch. Int. Med. **56**: 38, 1935.

83. Cutler, E. C., and Schnitker, M. T.: Total Thyroidectomy for Angina Pectoris, Ann. Surg. **100**: 578, 1934.

84. Berlin, D. D.: Therapeutic Effect of Complete Thyroidectomy on Congestive Heart Failure and Angina Pectoris in Patients With No Clinical or Pathological Evidence of Thyroid Toxicity. II. Operative Technique, Am. J. Surg. **21**: 173, 1935.

85. Clute, H. M.: Quoted by Parsons and Purks, ref. 90.

86. Reid, Mont R.: Quoted by Parsons and Purks, ref. 90.

87. Trout, Hugh: Quoted by Parsons and Purks, ref. 90.

88. Moore, John T.: Quoted by Parsons and Purks, ref. 90.

89. Lourie, O. R.: Is Total Thyroidectomy Rational as a Method of Treatment? A Critical Survey, Canad. M. A. J. **31**: 502, 1934.

90. Parsons, Willard, and Purks, W. Kendrick: Total Thyroidectomy for Heart Disease, Ann. Surg. **105**: 722, 1937.

91. Weeks, C.: Total Thyroidectomy for the Relief of Pain in Angina Pectoris, S. Clin. North America **16**: 667, 1936.

92. Hurzthal, L. M.: Heart Disease, New England J. Med. **211**: 61, 1934.

93. Blumgart, H. L.: Total Thyroidectomy for the Relief of Cardiac Pain and Congestive Heart Failure, in Robert L. Levy's Diseases of the Coronary Arteries and Cardiac Pain, New York, 1936, The Macmillan Company, Chapter XVI.

94. Hepburn, J.: Total Ablation of the Thyroid Gland in the Treatment of Angina Pectoris and Congestive Heart Failure, Canad. M. A. J. **32**: 390, 1935.

95. Levine, S. A., Cutler, E. C., and Eppinger, E. C.: Thyroidectomy in the Treatment of Advanced Congestive Heart Failure and Angina Pectoris, New England J. Med. **209**: 667, 1933.

96. Mixter, C. S., Blumgart, H. L., and Berlin, D. D.: Total Ablation of the Thyroid for Angina Pectoris and Congestive Heart Failure, Ann. Surg. **100**: 570, 1934.

97. Wolferth, C. C.: Total Thyroidectomy for Cardiac Failure, Ann. Surg. **101**: 1276, 1935.

98. Berlin, D. D.: Total Thyroidectomy for Intractable Heart Disease, J. A. M. A. **105**: 1104, 1935.

99. Cutler, E. C., and Schnitker, M. T.: Total Thyroidectomy for Angina Pectoris, Ann. Surg. **100**: 578, 1934.

100. Brenner, O., Donovan, Hugh, and Murtagh, B. L. S.: Total Thyroidectomy in the Treatment of Patients With Congestive Heart Failure and Angina Pectoris, Brit. M. J. **2**: 624, 1934.

101. Ochsner, Alton, and Gillespie, Crawford: Total Thyroidectomy for Cardiac Disease, New Orleans M. & S. J. **88**: 423 ,1936.

102. Berlin, D. D.: The Recurrent Laryngeal Nerves in Total Ablation of the Normal Thyroid Gland. An Anatomical and Surgical Study, Surg., Gynec. & Obst. **60**: 19, 1935.

103. Freedman, L. M.: Treatment of Angina Pectoris and Congestive Heart Failure by Total Ablation of the Thyroid. V. Importance of Laryngoscopic Examination as a Means of Preventing Bilateral Paralysis of the Vocal Cords, Arch. Otolaryng. **19**: 383, 1934.

104. Friedman, H. F., and Blumgart, H. L.: Treatment of Chronic Heart Disease by Lowering the Metabolic Rate. The Necessity for Total Ablation of the Thyroid, J. A. M. A. **102**: 17, 1934.
105. Lyon, J. A., and Horgen, E.: Dissociation of the Thyroid From the Sympathetic Nervous System and Reduction of Blood Supply to the Thyroid in Angina Pectoris, South. M. J. **27**: 985, 1934.
106. Friedman, B. B.: Angina Pectoris and Thyroid Gland; New Surgical Approach (Ligation of Arteries), Am. J. Surg. **33**: 124, 1936.
107. Fine, J., and Levenson, W.: Unpublished observations. Quoted by Blumgart, ref. 93.
108. Beck, C. S.: The Development of a New Blood Supply to the Heart by Operation, Ann. Surg. **102**: 801, 1935.
109. Beck, C. S.: Further Data on the Establishment of a New Blood Supply to the Heart by Operation, J. Thoracic Surg. **5**: 604, 1936.
110. Beck, C. S.: The Development of a New Blood Supply to the Heart by Operation, in Robert L. Levy's Diseases of the Coronary Arteries and Cardiac Pain, New York, 1936, The Macmillan Company, Chapter XVII.
111. Hudson, C. L., Moritz, A. R., and Wearn, J. Q.: The Extracardiac Anastomoses of the Coronary Arteries, J. Exper. Med. **56**: 919, 1932.
112. Moritz, A. R., Hudson, C. L., and Orgain, E. S.: Augmentation of the Extracardiac Anastomoses of the Coronary Arteries Through Pericardial Adhesions, J. Exper. Med. **56**: 927, 1932.
113. Beck, C. S., Tichy, V. L., and Moritz, A. R.: Production of Collateral Circulation to the Heart, Proc. Soc. Exper. Biol. & Med. **32**: 759, 1934-35.
114. Beck, C. S., and Tichy, V. L.: The Production of Collateral Circulation to the Heart. An Experimental Study, Am. Heart J. **10**: 849, 1935.
115. Beck, C. S.: The Heart as a Surgical Organ, M. Ann. District of Columbia **5**: 29, 1936.
116. Beck, C. S.: Coronary Sclerosis and Angina Pectoris. Treatment by Grafting a New Blood Supply Upon the Myocardium, Surg., Gynec. & Obst. **64**: 270, 1937.
117. Mautz, Frederick R.: Reduction of Cardiac Irritability by the Epicardial and Systemic Administration of Drugs as a Protection in Cardiac Surgery, J. Thoracic Surg. **5**: 612, 1936.
118. Reid, Mont R., and Andrus, W. DeWitt: The Surgical Treatment of Angina Pectoris, Ann. Surg. **81**: 591, 1925.
119. Cutler, E. C.: Summary of Experience Up to Date in the Surgical Treatment of Angina Pectoris, Am. J. Med. Sc. **173**: 613, 1927.
120. Yater, Wallace M., and Trewhella, Arthur P.: The Case For and Against the Operative Treatment of Angina Pectoris, Am. J. Med. Sc. **182**: 35, 1931.
121. Orth, Oscar: Ueber den derzeitigen Stand operativer massvolumen bei Angina pectoris, Klin. Wchnschr. **13**: 1320, 1934.
122. Sarasola, R. D.: Estado actual del tratamiento quirurgico de la angina de pecho, Arch. Cardiol. y hemat. 1927. Quoted by Danielopolu, ref. 38.

Review of Recent Meetings

REVIEW OF THE TWENTIETH ANNUAL MEETING OF THE AMERICAN ASSOCIATION FOR THORACIC SURGERY, SARANAC LAKE, N. Y., MAY 31, JUNE 1 AND 2, 1937

HERBERT A. CARLSON, M.D., MINNEAPOLIS, MINN.

(From the Department of Surgery, University of Minnesota)

THE outstanding feature of the meetings was an address by **Professor Hans C. Jacobaeus,** of Stockholm, Sweden, on **Bronchospirometry and Its Use in Determining Indications for Thoracoplasty in Bilateral Pulmonary Tuberculosis.** Jacobaeus has devised a double-barrel bronchoscope with which he can occlude the trachea and the right main-stem bronchus in such a manner as to provide separate channels of breathing for each lung. Recordings are made on two spirometers, one for each lung, so that the amplitude of respiration, the oxygen intake, the carbon dioxide output, minute ventilation, ventilation equivalent, and vital capacity of the two lungs may be compared. The functional test of the lungs obtained in this manner often gives one information not determined by x-ray examination or by any other method. No serious accidents have attended the use of this method.

Jacobaeus concluded from his bronchospirometry studies that pneumothorax in many instances, although it reduces the vital capacity, does not materially alter the efficiency of the lung in oxygenating blood. He found that in some instances the lung for which thoracoplasty was proposed was carrying the greater share of the respiratory load. Frequently the apparently healthy lower lobe which one attempts to preserve in performing thoracoplasty has very little functional value. In addition to its use in pulmonary tuberculosis, the method was employed in a study of cases of bronchiectasis and lung cyst.

Experiments were also carried out in which one bronchus was obstructed, or in which one lung was required to breathe nitrogen. In these cases it was found that the unobstructed lung takes over the function of both.

The presidential address was given by **Dr. Leo Eloesser,** of San Francisco, on bronchostenotic cavities and other closed foci of tuberculous suppuration in the lung. In this address the many phases of the subject were considered, somewhat in detail; illustrative cases were described in which contrast media had been injected through external openings. One of the important conclusions was that the obstruction of a bronchus to a tuberculous cavity is not necessarily beneficial as is often assumed, but that it may be harmful due to the blockage of drainage of a suppurative process.

Dr. Frank S. Dolley, of Los Angeles, read a paper on the treatment of ruptured lung abscess. He treats massive pyopneumothorax following sudden rupture of a lung abscess by complete and immediate drainage of the empyema cavity. A large thoracotomy is provided by resection of ribs and excision of intercostal

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bundles. A large dressing is applied, open drainage is maintained, but no drainage tubes are inserted at the time of operation. The patient rests on his back in a semisitting position. On the third day Penrose drains are inserted. The operation is recommended by the author because of its simplicity, the adequacy of drainage, and the almost total absence of sucking in the thoracotomy wound.

Dr. Harold Neuhof, of New York City, has employed free transplants of fat for the closure of pulmonary cavities remaining after the evacuation of destructive suppurative lesions. These cavities may range in size from very small defects to a lattice lung occupying much of a lobe. They are featured by bronchial fistulas, and if they do not heal spontaneously, they may be simple and easy of solution, or they may be difficult and complicated. The free transplant of fat has been employed in seventeen cases and was successful in eleven. The author admits that the use of free fat transplants, in the presence of infection, is a violation of principles of tissue transplantation that have been laid down in the past, but he advocated the method on the basis of clinical trial. The mechanism of healing of the cavities following the use of fat transplants is not as yet clearly understood.

Dr. Harry C. Ballon and Dr. Alton Goldbloom, of Montreal, reported on their experiences with prontylin and prontosil in the treatment of hemolytic streptococcus infections of the lung, pleura, and chest wall. The drugs were administered orally and intramuscularly. Intravenous administration was formerly used but has been discontinued. The oral dosage has been limited to sixty grains per day. The authors conclude that the dyes possess definite chemotherapeutic properties in the presence of acute and chronic infections due to the hemolytic streptococcus. Case reports were presented and a particularly striking result occurred in an apparently hopeless infection of the pleura, chest wall, and ribs complicating scarlet fever.

Dr. D. A. Wood and Dr. Leo Eloesser, of San Francisco, discussed the rôle of the dual pulmonary circulation in various pathologic conditions of the lungs. They reviewed the literature on the subject and presented a study based upon seventy-two injections of specimens. The authors conclude that increase in bronchial circulations occurs in (a) hypertrophic processes in pulmonary parenchyma; (b) obstructive lesions, pulmonary and cardiac, sclerotic, congestive, etc; (c) inflammatory lesions, chronic and acute; pulmonary, cardiac, and mixed; (d) processes of debatable etiology, emphysema, asthma, etc.; and (e) congenital anomalies. They found that dilatation of the bronchial artery occurs in primary pulmonary malignancy but not in metastatic tumors of the lungs. Hemorrhage occurs in primary neoplasms, but not in secondary. In ligation to control hemorrhage it may be necessary to occlude both the pulmonary and bronchial vessels. In such an instance a ligature is placed around the entire hilum, but not sufficiently tight to occlude the bronchus.

Dr. William S. McCann and Dr. Nolan L. Kaltreider, of Rochester, New York, reported on the effect of thoracoplasty on the pathologic physiology of respiration. They made measurements of the total pulmonary capacity and its subdivisions in chronic cases of pulmonary tuberculosis treated by thoracoplasty. In addition roentgenographic studies were made; the gaseous content of the arterial blood was determined. The venous pressure and blood velocity were measured and in six instances respiratory response during exercise was determined. These measurements were made from 7 to 127 months after operation. They found that thoracoplasty caused a marked reduction in total and vital capacity, the diminu-

tion being roughly proportional to the number of ribs resected. The reduction in the midcapacity and the residual volume were less marked for the other capacities, resulting in high normal values for the relative values. The ability to expand the chest in patients with thoracoplasty was greatly diminished. Its usual interference with the chest cage result in a slight or moderate anoxemia. In spite of the presence of arterial anoxemia, no evidence of polycythemia was found. The value for the venous pressure was slightly elevated but was not abnormally high. In about half the patients the velocity of the blood was slightly delayed. During moderate physical exertion patients with thoracoplasty operations had a rapid and shallow type of breathing compared with normal individuals. The expression "total ventilation" was abnormally high, and all but one patient complained of dyspnea on moderate exertion. The pulmonary reserve was reduced in all cases. Definite correlation existed between the degree of disability and the reduction in the vital capacity and the pulmonary reserve and the increase in the expression total ventilation. The authors conclude that thoracoplasty is more disabling than pneumothorax for the amount of lung collapsed.

Dr. Richard H. Overholt and Dr. John S. Harter, of Boston, reported on further observation on the lung volume after thoracoplasty. They found that thoracoplasty results in an irreversible and permanent alteration of the volume of the thorax. Lung volume and vital capacity determinations were made in a series of seventy-two thoracoplasty subjects. One-half of them have now been restudied six to eighteen months after completion of the operation. The results show alteration in the lung volume in both directions. Increase in the volume of the lung after operation was sometimes found to be as high as 24 per cent above the preoperative readings. The majority of cases showed a slight decrease in lung volume. The vital capacity in all cases showed a decrease of 8 to 30 per cent. The study suggests that the more nearly the operation approaches the ideal, i.e., selective collapse with preservation of functioning basal portions, the less change there is in the respiratory reserve.

Dr. Adrian Lambert, Dr. Frank Berry, Dr. W. Dickinson, Dr. J. Richards, and Dr. Andre Cournand, of New York City, discussed the methods for estimating pulmonary and circulatory capacity. Mechanics of breathing were studied by the use of respiratory tracings, lung volume and maximum capacity determinations, as well as by the more common methods of fluoroscopy, x-rays, and external chest measurements. Respiratory gas exchange was estimated by gasometric methods, analysis of expired air and of the arterial blood gases. Circulatory mechanics were studied by measurement of circulation time, venous and arterial blood pressures, and by the response of these and of the vital capacity to intravenous saline injection. In order to test the efficiency of breathing, the adequacy of the gas exchange, and the circulatory adjustments in changing physiologic conditions, these measurements were carried out at rest, during one minute of moderate exercise and during the period of recovery from exercise. It was found in these studies that ventilation may be reduced in emphysema even if the volume of the lung is increased. Illustrative clinical cases were presented.

Dr. B. N. Carter and Dr. J. J. Longacre, of Cincinnati, reported a study of changes in cardiorespiratory physiology following total pneumonectomy in young developing animals. The purpose of the paper was to determine the degree of compensatory return of function in young pneumonectomized animals and to contrast this degree of return of function with that in adult animals following

pneumonectomy. Studies were made upon a litter of six puppies. Adult dogs were also studied. Three of the puppies were pneumonectomized at the age of one month (the entire left lung being removed); the remaining three animals were kept as controls. Six months after pneumonectomy, all of the animals were subjected to strain experiments. These consisted of treadmill tests, anoxemia tests, and lung volume determinations. Observations were repeated at monthly intervals throughout the growth period. The authors concluded that true hypertrophy of the lung, rather than emphysema occurred in the young subjects. Furthermore, the younger the subject, the less was the respiratory embarrassment after pneumonectomy.

Dr. William H. Stewart and Dr. F. H. Ghiselin, of New York City, gave a beautiful demonstration of ciné fluorographic studies of thoracic diseases. By ciné fluorography is meant the making of a motion picture record of the image seen on the fluoroscopic screen. The difficulties surrounding this procedure have been greatly lessened by new developments in apparatus. Advantages of the method are that moving organs may be intensively studied at leisure as long as desired without undue exposure of the patient or the operator to the x-ray. It is relatively inexpensive and uncomplicated and furnishes a good library for teaching purposes. It is especially valuable in all lesions above the diaphragm. In this demonstration the film showing the pulsation of an aortic aneurysm and another showing the movement of lipiodol in a case of bronchiectasis were particularly dramatic.

Dr. Harold Brunn and Dr. H. B. Stephens, of San Francisco, gave a report of the successful removal of a carcinoma of the esophagus, together with a review of the cases treated at the University of California Hospital. The patient suffered from a moderately advanced carcinoma involving the midesophagus. The technique of Torek was employed. The value of preoperative pneumothorax, positive pressure, intratracheal anesthesia, and the prevention of a contralateral pneumothorax were stressed. The patient made a successful operative recovery.

Dr. Herman J. Moersch, of Rochester, Minn., discussed the successful treatment of carcinoma of the esophagus by means of surgical diathermy. A case of squamous cell carcinoma of the esophagus affecting a man sixty-eight years old was reported. The growth was destroyed by means of surgical diathermy in 1935. The patient is alive and well, with no evidence of local or metastatic recurrence of the growth, able to eat everything without difficulty and has gained twenty-one pounds.

Dr. Stuart W. Harrington, of Rochester, Minn., presented a moving picture demonstration of the management of teratoid tumors of the chest. He stressed again the value of the posterior incision in removing the majority of these teratoid tumors. He also emphasized the importance of early removal partly because of the fact that some of these tumors become malignant.

Dr. C. S. Beck, Dr. F. R. Mautz, and Dr. A. R. Moritz, of Cleveland, discussed the augmentation of collateral coronary circulation by operation. In the normal heart abundant anastomoses exist between the major branches of the coronary arteries and extracoronary arteries. There is considerable natural variation in the degree of such anastomosis, but functionally the coronary arteries are end arteries. As a result of chronic progressive obstruction of coronary arteries the intercoronary and extracoronary anastomoses enlarge. Symptoms of coronary disease are interpreted as failure of collateral blood supply to compensate for the disease. The Beck operation is designed to improve the collateral coronary

circulation in coronary disease. The mechanisms by which this may occur are: 1. Development of new intercoronary anastomoses to aid in the redistribution of blood in the myocardium. 2. Development of new extracoronary anastomoses to increase the total blood supply of the heart. 3. Increase in caliber of existing intercoronary and extracoronary anastomoses by hyperemia and tissue reaction.

Dr. Alfred Blalock and Dr. Sanford E. Levy, of Nashville, Tenn., gave a paper on tuberculous constrictive pericarditis with a report of cases treated by pericardectomy. Nineteen patients with chronic constrictive pericarditis were studied. The disease was believed to be tuberculous in origin in 16 patients and was proved to be tuberculous in 13. Pericardectomy was performed in 12 of the 19 patients; of these, 8 were proved to be tuberculous. The authors reported that of the patients with tuberculous pericarditis treated by pericardectomy, the early results were good.

Dr. Ralph Adams and Dr. Edward D. Churchill, of Boston, reported six cases of the syndrome situs inversus, bronchiectasis and chronic sinusitis. The frequency with which this association occurs in the hospital population is entirely beyond the possibility of mere chance. Embryologic theories as to the cause of situs inversus suggest that the bronchiectasis may be due to associated maldevelopment.

Dr. E. C. Drash, of University, Va., gave a paper on an appraisal of closed intrapleural pneumonolysis in pulmonary tuberculosis. The report was based on a series of more than two hundred personal cases and a survey of the literature. He stressed the importance of waiting until there is a fairly stable intrapleural pressure, usually requiring at least three months. The results were much the same as those that have been reported elsewhere. The author included among his complications several cases of tuberculous empyema occurring several months after the operation.

Dr. William F. Rienhoff, Jr., of Baltimore, described a two-stage operation for total pneumonectomy demonstrating a new technique for closure of the bronchus. In the first stage, through an anterior incision, the pulmonary artery is ligated; at the second stage, the pneumonectomy is completed. Emphasis was placed upon the dissection of the lymphatic glands. The author closed the bronchus by a new method. In this method a flap, prepared from the membranous portion of the bronchus, is folded over and sutured to the edges of the bronchial stump. This method may also be applied in the removal of the lower portion of the trachea. In the discussion that followed, **Dr. E. D. Churchill** presented arguments for the employment of lobectomy rather than total pneumonectomy for carcinoma. It was his belief that if carcinoma has already invaded the mediastinal nodes, even total pneumonectomy is futile. He, therefore, recommended that whenever the tumor appears to be limited to one lobe, lobectomy should be performed rather than risk the higher mortality of pneumonectomy. The question of thoracoplasty following total pneumonectomy was also discussed by **Dr. Rienhoff** and by **Dr. Evarts Graham,** and they both appeared to be of the opinion that thoracoplasty to obliterate the pleural cavity on the operated side is a desirable procedure.

Dr. Deryl Hart, of Durham, N. C., reported further on his experience with sterilization of the air in the operative region with bactericidal radiant energy. A study made to determine the number of bacteria in the air in the operating room demonstrated that after sterilization by ultraviolet light the number of

bacteria was decreased. It was also found that the operator and his assistant are carriers of *Staphylococcus aureus* in many instances, and that the gauze mask affords little protection. The author compared the results obtained in 110 thoracoplasties performed without sterilization of the air in the operative field with 100 similar operations performed in a field of sterilized air. The number of infections was reduced, the severity of infection, and the postoperative temperature elevations and durations were also reduced, and the general reaction of the patient was less when this method of sterilization was employed.

Dr. H. R. Decker, of Pittsburgh, reported on his experience with collapse therapy for pulmonary tuberculosis in the fifth and sixth decades. Of 200 patients in this series, 20 per cent were well and able to do some work, 25 per cent were improved, 25 per cent were unimproved, and 30 per cent were dead. The author found that the older patients do fairly well with phrenic nerve operations, closure of cavities occurring in 15 per cent. The beneficial results from phrenic nerve operations are in direct proportion to the extent of rise in the diaphragm.

Pneumothorax was less successful in younger patients. One reason for this is that a larger percentage have adhesive pleuritis, and here again there is a greater reduction in the vital capacity. Patients in this age group, however, should be treated vigorously by pneumothorax, but pneumothorax should be discontinued soon if collapse is unsatisfactory. The extent and duration of pneumothorax are important factors in the success of treatment.

One of the points particularly stressed in this report was the high mortality (27 per cent), in the thoracoplasty cases.

Dr. Owen H. Wangensteen, Dr. H. A. Carlson, and Dr. Warner F. Bowers, of Minneapolis, reported on partial thoracoplasty for pulmonary tuberculosis with a suggested plan of operation, including preliminary anterior chondrocostectomy, together with a review of the results. In the series of cases reported a preliminary anterior chondrocostectomy was performed which permitted removal of the upper three or four costal cartilages, together with a short segment of rib. About ten days later the upper-stage posterior operation is performed at which time the upper three ribs are completely removed. The complete excision of the ribs is greatly facilitated by the preliminary anterior chondrocostectomy. Additional operations are performed subsequently as required in the individual cases. Forty-seven patients operated upon in this manner were reported. There were two deaths in this series, but no deaths occurred after the upper-stage operation. Ten of the patients, in addition, had the extrafascial apicolysis described by Semb. Patients were followed six months to three years after operation. More than half of the patients had both closure of cavity and negative sputum at this time.

Dr. B. P. Potter, of Secaucus, N. J., discussed the management of the excessively mobile mediastinum in the surgical collapse of tuberculous pulmonary cavities. This paper dealt with a study of sixty patients in whom the mediastinum was fixed by artificial methods either during the course of pneumothorax or prior to thoracoplasty. The studies have been conducted for the past five years, and there has been a follow-up of from two to five years. The author believes that shifting of the mediastinum is a factor in the spread to the opposite lung. Shifting of the mediastinum also resulted in dyspnea, tachycardia, weight loss, and gastrointestinal complaints. Fixing of the mediastinum diminishes the risk of thoracoplasty. Methods that have been employed for fixing the mediastinum consisted of injecting gomenol, 2 to 5 per cent, in amounts varying from 10 to 15 c.c.;

mineral oil, in amounts varying from 10 to 15 c.c.; hypertonic salt solution, 7 per cent, in amounts up to 150 c.c. The oil or solution employed is injected into the pleural cavity, the patient lies on his sound side for one hour after the injection. Within twenty-four hours a small to moderate effusion usually develops. The temperature may be elevated, but usually returns to normal within seventy-two hours. The mediastinum must be retained in the desired position, and in some cases, it is necessary to withdraw air or fluid. Fixation is complete when no shift occurs with expiration following deep inspiration. Further injections of the liquid may be required in some cases. In the presence of adhesions there are dangers in injecting the oil. It was stated that the pleura thickened only moderately, and this thickening does not interfere with reexpansion of the lung in pneumothorax.

Dr. Fred R. Harper, of Tucson, Ariz., reported on the effect of phrenic nerve interruption on the gastrointestinal tract. He found that gastrointestinal symptoms developed following paralysis of either the right or left hemidiaphragm. The syndrome following paralysis of the left diaphragm is characterized by loss of appetite, fullness, nausea, and vomiting. Following a paralysis of the right hemidiaphragm, the characteristic symptom is primarily pain in the right upper quadrant. Roentgenograms taken before and after phrenic interruption show anatomic changes in the abdominal viscera sufficient in degree to explain the symptoms. Temporary phrenic interruption is advised in preference to permanent phrenic exeresis because in all of the observed cases the symptoms did not persist after the function of the diaphragm returned. The author felt that 25 per cent of the symptoms occurring were detrimental to the patient.

Dr. Pol N. Coryllos, of New York City, reported on the study of tuberculous empyema based on 150 personal cases. He found that tuberculous empyema is more likely to occur in the presence of a positive pressure in the thorax, and that a subpleural tuberculous focus is invariably present. When the oxygen in the pleural space is increased and the carbon dioxide is decreased, it is an indication of the presence of a bronchopleural fistula. The gas analysis test is of great value as it occurs prior to any other evidence of fistula. Dr. Coryllos classified tuberculous empyema into three groups: (1) the pure tuberculous empyema, with a positive sputum; (2) the pure tuberculous empyema with a negative sputum; and (3) the mixed empyema with either a positive or a negative sputum. He stressed the value of early thoracoplasty particularly in the first and third groups.

Dr. W. W. Woodruff, of Saranac Lake, N. Y., also gave a review of the results of treatment of tuberculous empyema. He found that oleothorax is sometimes effective in pure tuberculous empyema, but of no value in mixed infections. A patient with mixed infection has about one-half as good a chance to recover as one with a pure tuberculous infection. Bronchial fistula is an indication for drainage in tuberculous empyema. Of thirty-eight patients who had no surgical treatment for tuberculous empyema, 40 per cent are well and working, and 40 per cent are dead.

Additional short papers were presented by the physicians of Saranac Lake, N. Y., on the following subjects:

The Virulence of the Tubercle Bacillus Destroyed by the Action of the B. Macerans and the L. Pentoaceticus, by **Dr. H. A. Bray and Dr. Joseph Kurung**; **The Importance of Determining the Vitamin C Content in Fruits and Vegetables**

in the Treatment of Intestinal Tuberculosis, by **Dr. Mack McConkey; The Lymphatics of the Pleura in Relation to Cold Abscesses of the Chest Wall,** by **Dr. Hugh E. Burke; Immediate and Late Results of Hygienic-Dietetic Treatment of Pulmonary Tuberculosis,** by **Dr. Homer N. Sampson and Dr. Fred H. Heise; Venous Pressure in Collapse Therapy and Other Complications of Pulmonary Tuberculosis,** by **Dr. John Steidl.**

REVIEW OF THE ANNUAL MEETING OF THE AMERICAN ASSOCIATION FOR THE STUDY OF GOITER, DETROIT, MICH., JUNE 14, 15, AND 16, 1937

WALTER G. MADDOCK, M.D., ANN ARBOR, MICH.

(From the Department of Surgery, University of Michigan)

WITH the objective of bringing together each year men who will present the best that has been thought, said and done in the study of goiter and its allied problems, the association held its annual three-day conference in Detroit. **Dr. Nelson M. Percy,** of Chicago, as president of the Association, was chairman of the meetings. **Dr. Frank Lahey,** of Boston, was elected president for the ensuing year.

The following is a summary of the papers read:

The Thyrocardiac, by **Dr. Nelson M. Percy,** Chicago: In this address by the president of the Association, attention was called to the group of patients who have cardiac failure with hyperthyroidism. To aid in the diagnosis of this condition the following suggestions were made: First, any elderly patient with auricular fibrillation and a palpably enlarged or hard thyroid gland is a thyrocardiac and a candidate for thyroidectomy, unless proved otherwise. If mitral stenosis underlies the auricular fibrillation, the indication is even more clear. In the author's experience, 90 per cent of the cases of auricular fibrillation seen were due to hyperthyroidism. Second, any elderly patient presenting the symptoms of decompensation and having a palpably enlarged, firm or nodular gland should be considered a thyrocardiac and a candidate for thyroidectomy, unless proved otherwise. Third, in any case of failing health in a middle-aged to elderly patient, in which the entire clinical picture is not obviously due to another condition, some degree of hyperthyroidism should be suspected. Fourth, we should be goiter conscious. When looked for, hyperthyroidism will be discovered in many patients where it was never suspected before.

In the management of the thyrocardiac before, during, and after the operation all of the special considerations common to the care of middle-aged individuals with debilitating disease were shown to be necessary, and conducive in many cases to most brilliant results.

Revised Concepts of the Thyroid and Metabolism in Pregnancy, by **Dr. G. C. Shauffler,** Portland, Ore.: The general purpose of this paper was to indicate the actual confusion of thought on the relationship of the thyroid to female sex function. An appeal was made for closer cooperation between the obstetrician and the surgeon and internist particularly interested in the goiter problem, so

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that a greater unanimity of opinion concerning the care of thyroid disturbances during pregnancy should result. In the past two years the author has abandoned iodine administration to obstetric patients and because of frequent findings suggesting mild hypothyroidism among these patients has substituted desiccated thyroid therapy. The results were reported as justifying this treatment.

The Relationship Between Hyperthyroidism and Hyperparathyroidism, by **Dr. Andre Crotti,** Columbus, Ohio: Decalcification of the skeletal system during thyrotoxicosis has been noted for years. In over 50 per cent of the cases presented there was an average increase of 60 to 65 per cent in the calcium and phosphate elimination in the urine. In many patients definite symptoms result from this abnormality; joint pains, often excruciating, are not uncommon as a consequence of the subperiosteal decalcification, the pain being due to spicules of bone remaining. There may be profound muscular asthenia. In one case of long-standing, severe thyrotoxicosis coming to autopsy, typical changes of osteitis fibrosa cystica along with a fractured femur and normal parathyroid glands were found. This skeletal process was considered to be due to hyperparathyroidism induced by an overactive thyroid gland. Thyroid surgery produces a marked improvement or elimination of the decalcifying process.

Some Prognostic Criteria in Selection of Cases of Exophthalmic Goiter for Nonsurgical Treatment, by **Dr. Saul Hertz,** Boston: This report was a follow-up study of 24 patients first presented before the Society five years ago. Of the 24, 12 have since had thyroid surgery, 2 could not be traced, and on further study 1 appeared not to have a toxic goiter. The remaining 9 have been carried along on medical treatment; their basal metabolic rates have dropped below normal as a rule, and all except one have gained weight. All 9, after five years, are still free from evident hyperthyroidism. Additional cases have been followed in the meantime. As a prognostic test for candidates for medical management a drop of 15 to 20 per cent in the basal metabolic rate on iodine therapy was considered important. The patients selected had mild hyperthyroidism, were without evidence of cardiac damage or other complications which would require surgery, and as a group had an initial basal metabolic rate of less than plus 35 per cent. It was understood that medical treatment was indicated, and carried out, only when the physician had close contact with his patient, enabling him to see the patient at frequent intervals.

Iodine Response and Some Other Factors in Relation to Mortality in Thyrotoxicosis, by **Dr. J. Lerman,** Boston: In a series of 1,187 patients with toxic goiter seen at the Thyroid Clinic of the Massachusetts General Hospital, of whom 731 had adequate metabolic data, it was found that 3.4 per cent (25 patients) failed to respond to iodine. The mortality in the nonresponding group was 24.0 per cent; whereas, the mortality in the patients responding to iodine was 1.1 per cent. While an analysis of several factors did not adequately explain the failure to respond to iodine, it did show that a large portion of the mortality in this group occurred in elderly patients, running relatively low metabolisms and possessing nodular goiters and some form of heart disease. It was hoped that by concentrating one's effort on this small group of patients who do not respond to iodine the mortality in toxic goiter could be appreciably lowered.

Normal and Abnormal Iodine Metabolism—Its Relation to the Reticulo-Endothelial System, by **Dr. Joseph L. De Courcy,** Cincinnati: Evidence was presented by this author to show that blood iodine is not always increased in cases

of hyperthyroidism. This was interpreted to indicate that it is not the thyroid alone which controls iodine metabolism and regulates the level of blood iodine. The liver plays an important rôle in iodine metabolism, and in conditions in which the liver is damaged—as in cholecystitis and liver disease—blood iodine is increased and reaches a higher level than in hyperthyroidism. Recent animal experiments confirming these findings were discussed and were believed to indicate that it is the reticulo-endothelial system, especially the reticulo-endothelial cells of the liver—the Kupffer's cells—that primarily control iodine metabolism. The thyroid gland was thought to act as a stimulator of the reticulo-endothelial system rather than directly on iodine metabolism.

The findings were considered to indicate that the determination of the iodine content of the blood is valuable as a test of liver function rather than of thyroid function and that it may be so used clinically in surgical cases where liver damage is to be feared.

Recurrent Hyperthyroidism, by **Dr. Norris W. Gillette,** Toledo: The avoidance of persistent and recurrent hyperthyroidism should start at the time of the primary operation. Much grief to the surgeon and discomfort to the patient can be obviated at this time. A radical resection of all the tissue which may be degenerated will prevent many recurrences. When this complication does make its appearance, the patient should be treated first medically by adequate iodinization, rest, and sedatives. Where this treatment is inadequate, surgery should be reemployed. The first procedure should be eradication of all possible remnants of thyroid tissue, following which, if the patient still suffers from hyperthyroidism, a denervation of the adrenals may be employed.

Needless Thyroid Surgery, An Analysis of One Hundred Cases, by **Dr. A. S. Jackson,** Jackson Clinic, Madison, Wis.: This study reviewed 100 patients for whom thyroidectomy had been advised, but for whom on proper study the following disease conditions were found to be responsible for the disorder:

Nervous exhaustion	45
Physical exhaustion	21
Menopause	15
Miscellaneous	6
Colloid goiter	5
Septic tonsils	5
Psychosis	3
	100

Errors in the metabolic rate test were frequently contributory to the original error in diagnosis. Such tests must not be taken too literally except after repeated trial and with due regard for the attitude and condition of the patient at the time of the test. In case of doubt, an iodine test is often of great value and the failure to respond to it rules out exophthalmic goiter, provided the patient is not iodine fast. Two out of three patients having toxic adenoma respond favorably to iodine; one-third are made worse. In the absence of hyperthyroidism, a favorable response to iodine does not occur. The conditions found to be the proper diagnosis for the hundred patients reported may in some ways simulate hyperthyroidism, but can be and must be differentiated if needless thyroid surgery is to be avoided.

Comparative Anatomy and Physiology of the Thyroid Gland, by **Dr. George Crile,** Cleveland: The animals of the air, the earth, and the waters were all included in this interesting correlation of data on the thyroid, the adrenals, and

the brain. Man was pointed out to have a greater amount of thyroid than adrenal tissue in order to keep up his energy, not for a sudden burst in an emergency, but for continuous steady work such as no other animal can do. The cetaceans also—whales, porpoises—have larger thyroids than adrenals in order to keep up a high continuous oxidation for the supply of plenty of heat as a protection against their cold environment. All the other animals have adrenals larger than the thyroid.

In a search for some law of oxidation in the animals, the weight of thyroid glands, then of the adrenals, and finally of the thyroid plus adrenals plus brain was compared with the heat production. No correlation was found. When the brain weight alone was compared, a correlation was found: "One gram of brain tissue is associated with or requires the production of 12.5 Cal. in 24 hours, allowing ± 20 per cent variation." This law excepted only man and the cetaceans.

The brain is the spark plug governing the rate of energy. If the brain is large, the thyroid has to be large to supply the continuous energy needed.

The Urinary Iodine in Thyroid Disease, by **Dr. George M. Curtis and Dr. Italo D. Puppel,** Department of Research Surgery of Ohio State University, Columbus, Ohio: Dr. Curtis' presentation of this subject was both authoritative and instructive. The daily urinary excretion of iodine in central Ohio was shown to average 51 micrograms, the variations from 36 to 78 micrograms being found due to a nonconstant diet. For the inhabitants of five nongoitrous regions the normal urinary excretion of iodine was four times that of the inhabitants of five goitrous regions. This observation was considered to have a definite bearing upon iodine deficiency as related to the incidence of goiter. The form in which iodine is excreted has not been definitely determined, but from evidence so far it is in a more simple compound than thyroxine.

The majority of patients with hyperthyroidism have an increased loss of iodine in the urine, part of which is suspected of originating in an increased breakdown of the high iodine-containing thyroid hormone. Iodine from other tissues may be a source. Following thyroidectomy for various forms of goiter there occurs an increased loss of iodine in the urine, even for uniodized patients. It was surprising to find that following other operations—thoracoplasty, radical mastectomy, and spinal fusion—a similar increased loss of iodine occurs. It appears that a part of this postoperative loss of iodine comes from the tissues. The urinary iodine can be considered as having a significance in thyroid disease similar to that of urinary sugar in diseases of the pancreatic islets or urinary calcium in diseases of the parathyroids.

Clinical and Experimental Observations on Parathyroid Transplants, by **Dr. Herman K. Pinkus, Dr. Walter G. Maddock, and Dr. Frederick A. Coller,** University of Michigan, Ann Arbor, Mich.: In a review of the literature, fifty-nine cases of parathyroid transplants to humans were found. Twenty-three were done for the relief of chronic postoperative tetany and in only nine of these was improvement noted for a year or more, observation beyond that time generally recording a relapse. To possibly adapt the graft to the host, in two female cases of postoperative parathyroid tetany the parathyroid graft was first cultured for two weeks in a medium made up in part by the host's blood plasma, and then implanted. No improvement of the tetanic condition was noted in either of these cases. In a series of parathyroid homeotransplantations on white rats, poorer results were obtained when tissue culturing was employed between the taking of the graft and its implantation than when the

implant was made immediately. Clinically and experimentally, tissue culture did not improve the results of parathyroid homeotransplantations.

Interpretation of Basal Metabolic Rates in the Relatively Normal Individual, by **Dr. Walter Boothby and Dr. W. A. Plummer,** the Mayo Clinic, Rochester, Minn.: A presentation was given of the use of the Gaussian curve and the standard deviation in medicine. Their value was apparent in discussing the variability of the basal metabolic rate of an individual, between individuals, and between individuals with and without metabolic disease. On the basis of extensive data, the normal basal metabolic rate was found to be ± 13 per cent for males and ± 18 per cent for females. A further application of these mathematical aids was the determination of how many patients would fall in any given group and what proportion would be abnormal.

Evidence That Most Thyroid Disease Is Congenital, by **Dr. William B. Patterson, Dr. H. F. Hunt, and Dr. R. E. Nicodemus,** Geisinger Hospital, Danville, Pa.: Blood cholesterol studies revealed that rabbits, unlike human beings, develop a hypocholesteremia in the second and third trimesters of pregnancy. Total thyroidectomy in the nonpregnant rabbit produces a hypercholesteremia, but in the pregnant rabbit the usual hypocholesteremia results. Since the maternal thyroid gland had been removed, the observed increase in maternal metabolism was considered to be due to the absorption of large amounts of thyroxin from the feti. That this resulted in hypothyroidism in these feti was shown by the fact that their blood cholesterol was over 100 per cent higher than that of feti of normal rabbits. Also, the thyroid glands of feti of thyroidectomized rabbits were in a state of extreme hyperplasia in an unsuccessful effort to maintain normal fetal metabolism. The investigators considered that this hyperactivity before normal thyroid structure had been reached would in all probability produce permanent damage to the thyroid.

From blood cholesterol determinations on pregnant women and the infant at birth, it was found that when maternal hypothyroidism and hypercholesteremia exist, fetal hypothyroidism and hypercholesteremia are also present. Histologically, the human thyroid at birth is in a state of hyperactivity. There is little doubt that the fetal thyroid reacts to fetal hypothyroidism by hyperactivity and hyperplasia just as does the rabbit fetal thyroid. In later years, depending upon the iodine supply and the physiologic demands, the effect of this early strain may lead to clinically evident thyroid disease.

The Production of an Increase in Metabolic Rates of Thyroidectomized Rabbits by Certain Pituitary Extracts, by **Dr. D. K. O'Donovan and Dr. J. B. Collip,** McGill University, Montreal: Studies on the metabolism of rabbits, both normal and thyroidectomized, indicated that pituitary extracts contain a metabolic stimulant which in its time relation differs from the thyrotropic hormone. This substance produced a rapid, transient rise in metabolism soon after its injection and was considered to be closely related to or identical with the melanophore hormone.

The Management of Minor Complaints After Thyroidectomy, by **Dr. Howard M. Clute and Dr. Hollis L. Albright,** Boston: The authors presented a discussion of the following minor disturbances after thyroidectomy: (1) difficulty in breathing and swallowing; (2) changes in voice; (3) injuries to the superior and inferior laryngeal nerves with resultant changes in function of the muscles of the

larynx, pharynx, and soft palate; (4) poor scars; and (5) deformity of the contour of the neck. Methods to avoid or to treat these complications were presented in detail.

The Effect of Iodized Salt After Twelve Years' General Use Upon the Incidence of Goiter Operations in Southern Michigan, by **Dr. Roy D. McClure,** Henry Ford Hospital, Detroit: The conclusions of this author were briefly as follows: (1) In Michigan an existing deficiency of iodine in the diet can best be combated by the use of iodized salt. (2) When first used in Michigan, this iodized salt apparently increased the number of thyroid operations, possibly by activating a number of quiescent adenomas, for the increase occurred in the adenoma group. (3) The increase reached its peak in the second year after the introduction of iodized salt. From the Board of Health statistics, an increase in the death rate from goiter reached its peak in this second year. (4) Following the second-year peak the number of operations for toxic diffuse and toxic nodular goiter rapidly and steadily decreased, excepting for a slight increase during the last three years. (5) The incidence of endemic goiter has been reduced almost to nil by the use of iodized salt, and no ill effects have been noted. With no endemic goiter, toxic nodular goiter and toxic diffuse goiter are less apt to occur. (6) As publicity concerning iodized salt has fallen off, its sale has decreased. As a result, a few more goiters are seen in the school children and the number of goiter operations has slightly increased. (7) To combat this slump, greater publicity for iodized salt is needed; or should a law be passed making it mandatory for grocers to sell only iodized salt?

Unexpected Postoperative Hyperthyroidism, by **Dr. Ambrose L. Lockwood,** Toronto: The postoperative death of two patients operated upon for adenomatous goiter was reported. In one there was no evidence and in the other only slight evidence of hyperthyroidism preoperatively, so that the fatal termination in thyroid crisis was unexpected. Factors possibly contributing to the death of these patients—traction on the carotid sheath, epinephrine, ligation of large capsular veins, interference with liver function, and saturation with iodine—were discussed. The formation of a mortality committee within the Association for the recording of all deaths after thyroidectomy was suggested in the hope that by some sort of correlation greater knowledge concerning these unexpected deaths would result.

Further Observations on Malignancy of the Thyroid, by **Dr. C. W. Mayo,** Rochester, Minn.: This paper was chiefly concerned with the three-, five-, and ten-year survival rates of the 737 cases of malignancy of the thyroid gland seen at the Mayo Clinic from 1907 to 1936, inclusive. The three methods of treatment considered and the statistics were as follows:

TREATMENT	TOTAL CASES	SURVIVAL PERIOD		
		3 YR.	5 YR.	10 YR.
Thyroidectomy	112	68.6%	62.6%	52.9%
Thyroidectomy with irradiation	261	80.1%	73.7%	58.6%
Irradiation only	183	25.8%	20.7%	12.2%

From these data, thyroidectomy with irradiation was pointed out to be the most favorable method of treatment. In fairness it was mentioned that 40 per cent of the cases treated by irradiation alone were of a grade 4 type by Broder's classification. From a prognostic standpoint the papillary type of malignancy was most favorable, particularly if the growth was within an adenoma.

Malignant Adenoma of the Thyroid With Recurrences in the Cervical Veins, by **Dr. Allen Graham,** Cleveland Clinic, Cleveland: An interesting presentation was made on a selected group of four thyroid neoplasms in which the primary operation was followed by the development of local recurrences in the veins of the neck, without detectable evidence of distant metastases. The clinical findings were of adenomatous goiter and in only one case was malignancy suspected at the time of the operation. On pathologic examination the striking feature suggesting future trouble was the presence of tumor cells or tissue in the lumina of capsular veins. Postoperatively, many months passed before local recurrences were noted, and they tended to remain localized. This was consistent with the low order of malignancy in the primary tumor and in contrast to rapidity of recurrence and dissemination of highly malignant undifferentiated or diffuse carcinomas. In patients returning with a localized mass in the thyroid area two or three years or more after the removal of a thyroid tumor of low grade malignancy, recurrence in the veins should be kept in mind, and if possible, a complete, wide excision of the mass should be done.

REVIEW OF THE AMERICAN SURGICAL ASSOCIATION MEETING, NEW YORK, N. Y., JUNE 3, 1937

ALTON OCHSNER, M.D., NEW ORLEANS, LA.

THE president's address by **Dr. Graham,** entitled **Dr. Gross Looks In on the American Surgical Association,** was splendid and excellently presented. Dr. Gross returned to attend the meeting of the American Surgical Association fifty-eight years after its founding and conversed with Dr. Graham during the presentation.

The first paper, by **Frederick W. Bancroft, Margaret Stanley-Brown, and Erwin Chargaff** (New York) on **Postoperative Thrombosis and Embolism,** was based on studies made by the authors since 1928. They believe that in addition to dehydration, stasis, and trauma, which are important factors in the causation of thrombosis and embolism, there are also biochemical factors. Some persons are apparently potential clotters; whereas, others are potential bleeders. It is desirable to determine those patients who are potential clotters, because it is in this type of individual that postoperative thrombosis occurs. Postoperatively the plasma-clotting index is determined as follows: The normal plasma-clotting time which is 105 seconds is used as the numerator and the patient's clotting time is used as the denominator. Normally the index figure should be 0.8 to 1.05. Patients with values below 0.8 are potential bleeders; whereas, those with values above 1.05 are potential clotters. An increase of the calcium of the blood does not tend to produce coagulation. In their study they have made routine determinations both preoperatively and postoperatively to determine the potential clotters. For the postoperative treatment they have used early exercise of the lower extremities, the prevention of ileus and abdominal distention by means of the duodenal tube, the avoidance of tight bandages, the administration of food early in order to stimulate peristalsis, and the prevention of dehydration. In those patients in whom the test shows a potential clotting, a diet high in carbohydrates and low in proteins is given. Sodium thiosul-

phate, 10 c.c. of a 10 per cent solution, is given every day for four to five days. In their early series, approximately 34 per cent of the cases had a high index. In more recent series employing new tests, 12 per cent to 14 per cent of patients examined were potential clotters. By the institution of prophylactic measures in instances in which the plasma-clotting index is high, they have been able to decrease materially the incidence of thrombosis.

Dr. John Homans (Boston), in discussing the paper, stated that he felt that it was desirable to pay more attention to the physical measures in the prevention of thrombosis than the biochemical measures suggested by the authors. He advises elevation of the lower extremities postoperatively, and the avoidance of the sitting posture, because this apparently decreases the rate of blood flow through the venous system.

Dr. Howard Lilienthal (New York), in discussing the paper, suggested the use of leeches not only as a curative procedure, but also as a prophylactic one, and stated that he uses four leeches on the fifth to the ninth day in all of his abdominal operative cases.

Dr. Charles C. Lund (Boston) presented a paper on **Embolectomy in Peripheral Embolism** in which he reported 55 cases of peripheral arterial embolism, most of which were associated with heart disease. About 90 per cent of the patients had auricular fibrillation. About half the patients had mitral stenosis; whereas, the remainder had arteriosclerotic heart disease. Although there is frequently some confusion in differentiating between thrombosis and embolism, Lund is of the opinion that whenever a sudden occlusion of an artery occurs it is always produced by embolism. Included in his series were all cases of sudden blockage of the major vessels of the periphery which were admitted to the hospital within a week after onset. Approximately half the cases had the onset of embolism before admission to the hospital; whereas, the others had their onset while in the hospital and most of them occurred on medical service. Twenty-three cases had been operated upon, 30 operations in all being done. There was a 44 per cent mortality rate, and 37 per cent obtained good functioning results. In more recent series, the mortality rate has been lower and the incidence of good results has been higher. In the 29 cases in which no operation was done mortality rate was 85 per cent and the successes were only 8 per cent. Lund concluded from his observations that embolectomy was not justified in upper extremity embolism, because the reestablishment of circulation occurred in every instance whether embolectomy was done or not. In cases of embolism involving the lower extremity, however, embolectomy should be done and done early, because the danger of developing gangrene is great. This is particularly true in embolism of the iliac and femoral arteries.

In discussion, **Dr. Harry Kerr** (Washington, D. C.) reported a case of saddle embolism at the bifurcation of the aorta which he operated upon by an abdominal section. The embolus was removed and the patient did well until the eighth day when there was a recurrence of the embolism. This time he approached the embolism by exposing the femoral artery under local anesthesia and sucking out the clot from below. He states that he has used it in one arm case with good results.

Dr. Albert Singleton (Galveston) reported a case of embolism of the brachial artery in which at operation it was found that the clot extended below the site at which the artery was opened. This was removed by massaging the arm from

below upward. After closing the artery, there was no return of the pulse. However, the artery was again opened and this time a small needle was introduced into the radial artery at the wrist and the artery flushed out with sodium citrate solution which ended in a good result.

Dr. Edwin Beer (New York) reported four saddle emboli cases. One was operated upon transabdominally and ended fatally. In two others the clots were sucked out by means of a well-lubricated catheter introduced into the femoral artery, but both patients succumbed. One of these showed the futility of attempting to remove a saddle embolus through the femoral because the clot extended up to the diaphragm. A fourth case was not operated upon, and the patient recovered with the loss of one great toe.

Dr. I. A. Bigger (Richmond) had had two cases with saddle emboli. One resulted in extensive gangrene of both legs and the other was operated upon fifteen hours after onset. It was his intention to open the aorta, but this was impossible because of the extensive calcification. One of the iliacs was opened and the clot sucked out. The operation was unsuccessful and gangrene subsequently developed.

Dr. Lund in closing the discussion stated that he had not seen any saddle emboli, but that he had had two bilateral cases. In both of these the emboli were removed through the femoral, one successfully and the other unsuccessfully. He prefers to approach an embolus from below than from above. With regard to the ultimate outcome of these patients and whether the operation was desirable, even in patients with heart disease, he states that in the Swedish embolectomy series one-fourth of the patients died within the first year, one-half died within three years, one-third were alive after five years, and one-eighth were alive at the end of ten years. These results are good enough to warrant the operation.

Dr. E. R. Schmidt and Dr. Ralph Waters (Madison, Wis.) in discussing **Anesthesia and Surgery** stated that the difficulty in obtaining anesthesia is directly proportionate to the metabolic rate. Preoperative medication lowers the metabolism and fright, emotion, fever, and thyroid activity increase it. By knowing the various planes of anesthesia and at which plane the various reflexes are abolished, it is possible for the anesthetist in cooperating with the surgeon to keep the patient at the optimum plane of anesthesia. Whereas a prolonged operation with the patient under light anesthesia is relatively safe, a short operation with the patient in deep anesthesia is dangerous. Clamping and pulling of the peritoneum produces a reflex which requires a deep anesthesia and should be avoided in closing the abdomen. Careful cooperation between the surgeon and anesthetist is important.

Dr. Waters in discussion stated that the anesthetist occupied a place between the surgeon and the laboratory and that he could be of great value to the surgeon in reducing morbidity and mortality.

Dr. A. W. Elting (Albany, N. Y.) stated that in the past there has been relatively little interest in anesthesia and he feels that a new era is being opened. The need for places for training for anesthetists is becoming greater, and with the increased number of well-trained anesthetists, anesthesia will improve.

Dr. Howard C. Naffziger, Dr. Frederick Foote, and Dr. Jesse Carr (San Francisco) discussed **Obstructive Jaundice: The Cause and Prevention of the Bleeding Dyscrasia.** Sulfur compounds in the blood of humans and animals with jaun-

dice increase the tendency toward bleeding. The two substances which are most likely to increase the hemorrhagic tendency are cysteine and methionine. Animals with jaundice produced by ligating the common duct if fed on a high protein diet exhibit an increased hemorrhagic tendency; whereas, if they are fed on low protein and high carbohydrate diet, there is a decreased tendency to hemorrhage. Whereas the normal plasma-sulfur content is about 70 mg. per 100 c.c., in jaundiced animals it is elevated to from 80 to 100 c.c. In a series of patients the normal plasma-sulfur value varied from 50 to 60 mg. per 100 c.c., but in patients with jaundice, it varied from 50 mg. to 130 mg. In the presence of jaundice it is important not to administer a high protein diet, but the patient should be fed a high carbohydrate diet, and in order to facilitate and accelerate the sulfur metabolism, they should receive glucose intravenously.

Dr. Waltman Walters (Rochester, Minn.), in discussion, stated that in addition to the intravenous administration of glucose it is important that the jaundice be relieved by operative measures. He believes that bleeding has become an unimportant cause of death in jaundice, as relatively few of their cases which they have lost have been from this cause.

Dr. Roscoe Graham (Toronto) stated that Ivy bleeding time is important as a test for a hemorrhagic tendency in jaundice. He does not operate upon patients with jaundice unless the Ivy bleeding time is less than four minutes.

The experimental production of hypertension was discussed in three excellent papers. **Dr. Dallas Phemister and Dr. Keith Grimson** (Chicago) studied the early and remote effects of total and partial sympathectomy on experimental hypertension. They found that hypertension produced experimentally by means of partial obstruction of the renal artery was not affected permanently by total sympathectomy. Following total sympathectomy there were no changes in the blood volume or the blood viscosity, but the cardiac output was definitely decreased. The temporary lowering of the blood pressure following various types of sympathectomy was always followed by a rise to the normal preoperative level.

Dr. Alfred Blalock and Dr. Sanford Levy (Nashville) studied the renal hypertension produced experimentally in dogs by the application of clamps to the renal vessel. They found that as long as some of the blood supply in the kidney remained intact, even only through the ureteral vessels, the increase in pressure did not remain, definitely showing that a pressor substance was formed in the ischemic kidney which caused an increase in blood pressure. This was demonstrated best in a transplantation experiment in which one kidney was transplanted into the neck, the renal artery and vein being anastomosed to the carotid and jugular vein, respectively, and in which the other kidney was removed. In this way all of the nerve supply to the kidney was removed. Partial occlusion of the renal artery supplying the transplanted kidney caused an increase in the blood pressure, showing that the pressor substance was formed in the kidney in which the blood supply was diminished. The resection of the splanchnic nerves and partial adrenalectomy as suggested by Adson were unsuccessful in relieving the hypertension thus produced.

Dr. George Heuer, Dr. Frank Glenn, and Dr. Charles Child (New York) also produced hypertension experimentally by constricting the artery of a single transplanted kidney. In their experiments a kidney was transplanted into the lumbar region and the renal vessel anastomosed to the femoral vessels. The Goldblatt clamp was applied to the femoral vessels after the transplantation following the removal of the opposite kidney. Although there was an increase in the

blood pressure following the clamping of the blood supply to the transplanted kidney, this did not remain elevated. Because the hypertension did not remain when the transplanted kidney was maintained ischemic, they believe that the renal nerves play no rôle in elevation of the blood pressure following clamping of the renal artery but that they may play a rôle in maintaining it.

In discussing these three papers, **Dr. Alfred W. Adson** (Rochester, Minn.), stated that clinically many mistakes had been made in the surgical treatment of patients with hypertension, as the methods and patients had to be chosen by trial-and-error methods. Many of the patients were relieved, however, although many were not. They have done three types of procedures. Rhizotomy was done in 37 cases. Most of the cases which they have operated upon, however, have been treated by resection of the splanchnic nerves and the first lumbar ganglia. This treatment has been used in 87 cases. Unless they have gotten a definite decrease in the blood pressure to within normal limits by the use of conservative measures such as rest in bed, the use of amyl nitrate and barbiturates, they feel that the operation should not be done. In their series of cases, they have only had two deaths, those occurring in the patients having rhizotomy.

In closing the discussion **Dr. Heuer** stated that their results had differed from Adson's in that in several cases which had not responded well to the conservative measures they were agreeably surprised to obtain beneficial results following the rhizotomy.

Dr. Walter E. Dandy (Baltimore) discussed **Intracranial Pressure Without Brain Tumor: Diagnosis and Treatment.** During the past seven years he has observed twenty-one cases which have offered diagnostic and therapeutic problems. These patients have been admitted to the hospital with the diagnosis of brain tumor. All had the symptoms of brain tumor, such as headache, vomiting, double vision, and dizziness. In every instance there was an increase in the cerebrospinal fluid pressure. In differential diagnosis brain tumor and optic neuritis must be considered. The diagnosis is made by ventriculography. The treatment of the condition consists of decompression which gives permanent relief. One of the characteristics of the condition is that the pressure is likely to vary, there being a rapid increase in the pressure, subsequently followed by a relatively rapid decrease. The cerebrospinal fluid is otherwise normal. The cause is not known. Its course is unchanged by fluid intake and also by fatigue. **Dr. Adson,** in discussion, suggested that the condition may be due to an encephalitis. **Dr. Wilder Penfield** (Montreal) asked whether the condition was not due to an increase in the subdural fluid content resulting from a mild inflammatory reaction, in which condition there is always an increased protein content of the fluid. **Dr. Dandy** in answering this question stated such was not the case, because in each instance the fluid was under the arachnoid.

Dr. Claude Beck and Dr. Frederick Mautz (Cincinnati) presented **Control of the Heart Beat by the Surgeon,** in which the effects of atmospheric pressure, torsion, traction, angulation, and various stimuli on the heart were graphically shown. They showed that the exposure of the heart to atmospheric pressure increased the venous pressure from 4 to 6 cm. of water, which normally would do no harm but which might be very detrimental to the diseased heart. Torsion and angulation of and pressure on the heart greatly increased the venous pressure. Traction in the direction of the long axis produced little change, both on the venous and the arterial pressures. By stimulating the heart electrically with

faradic current, it was possible to produce extra systoles. By using a stronger current, it was possible to produce ventricular fibrillation which resulted in the immediate fall in the blood pressure to a dangerous level. If this were allowed to continue, the heart dilated until it extruded from the thorax, and the animal ultimately died. By massaging the heart manually, however, it was possible to increase the tone of the heart muscle, and to increase arterial blood pressure so that the corneal reflex returned. By shocking the heart electrically it was possible to reestablish the normal rate of the heart in about half the instances. After applying cocaine or metycaine to the surface of the heart it was possible by shocking the heart to reestablish the normal rate of the heart in every instance. Dr. Beck suggests the availability of electrical connections and the use of metycaine and cocaine in all operations on the heart because of the possibility of establishing a normal rate in individuals in whom ventricular fibrillation occurs during the operation and from which they would otherwise not recover.

Professor Henri Coutard (Paris) discussed **Cancer and Radiation: Results and Methods of Treatment,** and reported 46 cases of lymphosarcoma treated with x-ray with 34 per cent five-year cures; 66 cases of palatotonsillar tumors of which 32 per cent were cured; 126 tumors of the larynx with 24 per cent five-year cures; 225 tumors of the pharynx with 11 per cent cures; and 8 cases of inoperable epithelial tumors of the maxillary sinus with 50 per cent five-year cures. Most of their cases of maxillary sinus epithelioma were treated by surgery and radium implantation. Nine hundred and eighty-four cases of uterine cervical cancer treated by x-ray and radium, using x-ray first, followed by radium implantation, gave 31 per cent five-year cures. Ninety-seven were in Group I, with 60 per cent; 336 in Group II, with 50 per cent; 411 in Group III, with 24 per cent; and 112 in Group IV, with 5 per cent five-year cures. In cancer of the tongue, interstitial irradiation, external radiation, and surgical removal of the glands of the neck were used. There were 382 cases with 18 per cent five-year cures. One hundred and ninety-eight cases of cancer of the anterodorsal region of the tongue gave 22 per cent cures. Ninety-one cases with cancer in the posterodorsal region gave only 10 per cent cures. There were 93 infralingual tumors with 18 per cent cures. Radiation affects both the tumor itself and the vasculoconnective tissue by destroying the cancer cell in the former instance, whereas, in the latter there is likely to be a fibrosclerotic transformation of the vasculoconnective tissue. In the undifferentiated tumors, irradiation is likely to be followed by success, particularly if it is located in loose connective tissue, but when located in dense muscular tissue because of the fibrosclerotic transformation of the vasculoconnective tissue, viable cancer cells may remain in fibrous tissues. In the differentiated cells, as in adenocarcinoma of the breast, the results from x-ray or radium are likely to be poor. Differentiated tumors, particularly in areas in which connective tissue is dense, are best treated by surgery. Preoperative irradiation is desirable; postoperative irradiation should be reserved only for recurrence. Adenocarcinoma is much more difficult to cure by irradiation than is stratified epithelium. In those cancers of the lip in which the cells are differentiated, the cervical glands are removed operatively.

Dr. Vilray P. Blair and Dr. J. B. Brown (St. Louis) in discussing **The Treatment of Cancer of the Mouth and Lip** stated that the treatment of cancer of the tongue is best done by interstitial irradiation. Buccal mucosal carcinomas are best treated by surgery. Prior to 1932, they did one-stage resections of the primary tumor and the cervical glands with a 33 per cent mortality rate. Since this time they have performed two-stage operations and in those cases in which the neck glands

were not fixed there were no deaths. They are of the opinion that every patient with a cancer of the lip should have a prophylactic dissection of the neck in order to obtain a cure.

Dr. James Ewing (New York) spoke on **The Development of the Laboratory Service in a Cancer Hospital.** The importance of cancer institutes and cancer hospitals was stressed, because only by the study of a large number of adequately supervised cases in one institution can advancement in understanding and the treatment of cancer be made. By such studies, it is possible particularly in many of the transitional tumors to determine their true nature. Aspiration biopsy has been condemned as dangerous by many, but Ewing believes that it is a reliable and valuable procedure, particularly when done properly as is performed in the large cancer hospitals. It is necessary in the large cancer hospitals to have the services of the preclinical and fundamental sciences, such as physics, chemistry, physiology, and pathology.

Dr. John J. Morton (Rochester, N. Y.): **The Etiology of Cancer in the Light of Our Present Knowledge.** The knowledge concerning the cause of cancer is derived from three sources: first, the natural occurrence in human beings and the relationship to apparent inciting agents; second, the production of cancer in certain occupational diseases, such as radium and x-ray; and third, the experimental production of cancer in animals. The inciting factors of cancer are first physical, second chemical, and third biological. All the processes which produce cancer start within the cell. This is a self-perpetuating mechanism and one which is no longer dependent upon or related to the inciting factor. The fundamental intercellular changes might be due to hereditary constitution, chemical changes, and other factors.

Dr. Leo Eloesser (San Francisco) in **The Treatment of Some Abdominal Cancers by Combined Radiation and Cautery Incision** presented a moving picture of cases in which at the time of operation the small intestine was packed out of the way and protected so that the large intestinal cancer could be irradiated with the abdomen open.

Dr. Joe Vincent Meigs (Boston): **Cancer of the Cervix Treated by the Roentgen Ray and Radium.** A series of 70 cases of carcinoma of the cervix treated by roentgen ray and radium is reported, of which 35 per cent are living and well without disease for three and one-half years. Only 11 per cent were early cases. The technique which the authors have used in the Pondville series consists of the use of a definite amount of radium given in two equally divided treatments in the cervical canal only and given four days apart immediately after irradiation by roentgen ray is finished. The x-ray is given through four portals of entry, each field receiving a total of 1,500 to 2,000 r. units. This is usually completed in an average of fourteen days. Daily exposures of from 300 r. to 600 r. are used, alternating the field, so that a given area receives an exposure every fourth day. At each application of radium 1,500 millicurie hours are given. On the morning of the fourth day a similar dose is reapplied to the cervical canal, making a total of 3,000 millicurie hours applied to the cervix in two divided treatments, four days apart. This method of therapy has given very good results and produces little reaction. Often following roentgen ray treatment the tumor becomes smaller, firmer, and less infected. Nineteen (27 per cent) showed a real shrinkage of the tumor following x-ray treatment. Grade II cancers showed a greater percentage of shrinkage of tumor than did Grade III.

Mr. Geoffrey Keynes (London) discussed **The Place of Radium in the Treatment of Carcinoma of the Breast.** The operative treatment of cancer of the

breast has not been very satisfactory and because of this the author has resorted more and more as time has gone on to radium irradiation. He does not believe in Handley's conception of cell permeation but is of the opinion that cancer spreads entirely by lymphatic embolism. In 1922, he began using radium interstitial irradiation in cancer recurrences. In 1924, he began treating inoperable primary tumors of the breast. He treated 50 inoperable cases and at the end of eight years had 10 per cent of them living and well. He now treats earlier cases of cancer with interstitial radiation. He frequently removes the tumor or breast followed by irradiation but never does an axillary dissection. In those cases in which he examined the removed tumor nine months or more after the irradiation, he found that 50 per cent of the cases showed no remaining tumor cells. He felt because the other 50 per cent showed viable cells that the large bulk of the tumor had prevented complete destruction, and that in such instances when the tumor was large it was best to remove the tumor before irradiation. The radium needles are placed in the plane between the breast and the muscles, but from his experience he is convinced that removal of the axillary gland is unnecessary. It may actually do harm in those cases in which the glands are large and is unnecessary in those cases in which the glands are small or absent. He advocates local excision of the tumor when the tumor is small or when the diagnosis is uncertain to be followed by irradiation of the breast and axilla. If the tumor is large, simple removal of the breast without removal of the muscle followed by irradiation is done. The results obtained are about the same obtained from surgery because death is due to distant and not to local metastases. In all he has had 325 cases, 250 of which were followed from 1924 to 1934. There are 85 cases in which the disease was localized to the breast, of which 83.5 per cent were well after three years, and of which 71.4 per cent were well after four years. There were 91 cases in which the disease was localized in the breast and axilla, of which there were 51.2 per cent three-year cures and 29.3 per cent five-year cures. There were 74 cases which were definitely inoperable, of which there were 34.1 per cent three-year cures and 23.6 per cent five-year cures. As the axilla was not exposed in his cases, it is probable that in many of the cases in which he assumed there was no axillary involvement such actually had occurred, so that, correcting for this error, he believes that the three- and five-year cures should be 94.8 per cent and 86.3 per cent, respectively. Irradiation is much better than operation, because it is attended with a much lower mortality rate, and there is less danger of dissemination of the disease when it has once gotten in the axillary nodes.

Dr. S. W. Harrington (Rochester, Minn.): **The Relationship of Pregnancies to the Surgical Treatment of Carcinoma of the Breast.** The breast carcinoma cases treated at the Mayo Clinic were divided into two groups, those which developed cancer during pregnancy and those in which pregnancy occurred after removal of a breast for cancer. There were 92 patients in whom a cancer of the breast developed during pregnancy, of whom 88 were traced. There were 55 patients in whom the breast had been removed for cancer and who subsequently became pregnant, all of whom were traced. Of the 92 cases in which a cancer of the breast developed during pregnancy, there were none in Grade I; 5.4 per cent were Grade II, 21.7 per cent Grade III, and 59.8 per cent Grade IV. Thirteen per cent were not graded. Of these 92 cases, there were 84.8 per cent with metastasis, of which none lived, and 15.2 per cent without metastasis. There were 55 cases operated upon which subsequently became pregnant. Whereas the pregnancy occurred from one to thirteen years after operation, most of them occurred between one to three years. There were 13 cases from between one and two years after operation, and 15 between two and three years. The grading of the tumors

in these cases was as follows: Type I, 4 cases; Type II, 8 cases; Type III, 15 cases; Type IV, 11 cases; and in 17 cases the tumor was not graded. Forty-five and five-tenths per cent had axillary metastasis, whereas, 54.5 per cent had none. The results obtained in this group were as follows: Of those surviving one or more years, there were 33 of 37; two or more years, 29 of 37; three or more years, 26 of 35; five or more years, 24 of 31; ten or more years, 12 of 18; and fifteen or more years, 7 of 12. Although these results seem to indicate that pregnancy occurring in a woman who has previously had a carcinoma of the breast does not offer as hopeless a prognosis as previously thought, it is Dr. Harrington's opinion that a woman who has had a carcinoma of the breast should be warned that she should not become pregnant.

Dr. L. S. McKittrick (Boston) **(Interstitial Irradiation in Breast Tumors)** began interstitial irradiation of breast tumors in 1913. His technique differed somewhat from that of Mr. Keynes in that the needles were placed between the breast and the muscle and also above the tumor in the breast. A gridiron method of introducing the needles was used. Almost immediately after the removal of the needle, the tumors began to decrease in size and the decrease frequently continued for four to five months. He has had 40 cases, 10 of which were operable, 20 inoperable, and 10 recurrent. There were 3 deaths. In the operable tumors there was complete regression of the tumor in 60 per cent. There was 50 per cent or more regression of the tumor in 12 per cent and less than 50 per cent regression in 28 per cent. He believes that the size of the tumor has a great deal to do with the ability of the radium to produce regression. Based on his results, he is of the opinion that in operable cancer of the breast irradiation is less desirable than surgery, because of the finding of viable cells in the irradiated mass in the large percentage of cases and because of the deformity and the pain following irradiation. He is also of the opinion that irradiation does not protect the axilla from invasion by the tumor.

Dr. Carl Eggers (New York) discussed **The Value of Radical Operation for Cancer in the Presence of Involved Lymph Nodes.** In the treatment of cancer the removal of the regional lymph nodes is of importance for cure. Involvement of the axilla in cancer of the breast should never keep one from doing a radical operation. In his mammary carcinomas, Eggers obtained five-year cures in 43.8 per cent, 33.3 per cent with axillary lymph nodes and 65.4 per cent without nodes.

Dr. Rudolph Matas (New Orleans) in discussing these papers emphasized that, although great advance has been made in the x-ray and radium treatment of cancer, at the present time these should be used merely as adjuncts and that the surgical removal of the tumor is most important. In closing the discussion, **Mr. Keynes** stated that for a number of years he had done routine biopsy and had observed no errors between the clinical diagnosis and that obtained histologically. Because, however, he obtained a recurrence in the skin wounds, he discontinued this procedure. At the present time he frequently removes either the tumor or the breast, and states that in no instance did he use irradiation in which the diagnosis was not definite either clinically or pathologically.

Dr. Loyal Davis (Chicago) discussed **The Results of Radiation on Gliomas of the Brain.** In considering the good effects obtained following x-ray treatment of brain tumors, frequently one has a false conception and does not take into consideration the results obtained from the operative removal of portions of the tumor and the decompression resulting from the operation. In the examination of cases previously operated upon and in which at the time tumor tissues were

removed and then subsequently irradiated, the author could find no correlation between the amount of deep x-ray treatment and the histologic change. Histologic examinations following irradiation of glioblastomas show more central necrosis and greater growth of collagenous tissues than in the untreated tissue, but there is apparently little inhibition of the growth of the tumor at the periphery. Clinically one is likely to be misled from results obtained from the irradiation.

In discussion **Dr. Elliott Cutler** (Boston) stated that irradiation definitely prolonged life in many of these patients, particularly in cases with medulloblastoma. These tumors are likely to recur, but by irradiation they have increased the survival rate from one year to six years in a number of cases.

Dr. F. L. Reichert (San Francisco) believes that x-ray is advantageous in treatment of these cases clinically. Recently they had been using heat applied directly to the brain substance by means of the high frequency current, which produces a destruction of tissues a considerable distance away from the site of application. In these cases, however, they are not using irradiation.

Mr. Julian Taylor (London) stated that although frequently there is little change in the histologic appearance of the tissue following irradiation, the clinical improvements are frequently very striking. For some time in those cases with a tumor on the left side of the brain in which he felt reasonably certain by a process of elimination the lesion was a glioma, he has employed only deep x-ray irradiation and has been very agreeably surprised at the improvement which these patients have obtained in that their choked discs and hemiplegia have disappeared.

Dr. W. E. Gallie (Toronto) in discussing **The Treatment of Fracture-Dislocation of the Cervical Spine** stated that they had been disappointed in the results obtained from reduction of cervical fractures because of too much danger of damage to the spinal cord. He advocates skeletal extension by means of ice tongs placed in the parietal bones. Whereas previously they used extension for a long time, recently they discontinued this because they observed cases with compression of the fifth cervical nerve. They now use very heavy traction for a period of minutes, following which they apply a head jacket cast, the whole procedure taking about an hour. Thirty to forty pounds of weight are applied for ten to twenty minutes and usually in this time satisfactory reduction is secured. This can frequently be facilitated by gentle manipulation. When the articular facets become locked, open reduction by levering the facets into place may be necessary or even resection of one of the facets. Reduction in fresh fracture is very much easier than in old ones. In the latter recurrence is likely to occur and because of this the author advocates spinal fusion according to the method of Hibbs which they have been using for four years.

Dr. F. J. Cotton (Boston) suggested the wiring together of the spinous processes instead of the fusion operation.

Dr. Frayer Gurd (Montreal) states that in Montreal they have been fusing the skull to the cervical spine by means of grafts from the ileum.

Dr. William Darrach (New York) discussed mild injuries of the cervical spine with unilateral subluxation. In nine years they have had 134 cases. These usually follow a mild injury, such as forcefully turning the head, sneezing, or some other trivial injury. The head is usually fixed in position and resembles torticollis. The diagnosis is made by means of stereoroentgenograms. In the mibler cases reduction is secured by rest and gentle traction, using a gravity pull on an air mattress with the head in hyperextension. The head is then fixed in a plaster cast.

Dr. William Jason Mixter (Boston): **Rupture of the Lumbar Intervertebral Discs as a Cause for So-Called Sciatic Pain.** Frequently cases of low-back pain associated with sciatica are the result of rupture of the intervertebral disc and extrusion into the spinal canal. Sixty per cent of these come on immediately after injury, aggravated by bending and lifting, relieved by lying down, and there is frequently tipping toward the affected side. There is limitation of straight leg raising. There is also an absence of diminution of ankle reflex on the affected side. The x-rays occasionally show narrowing of the intervertebral disc, but this is seldom found. In cases of low-back pain associated with sciatica unrelieved by conservative orthopedic measures the patient should have a lumbar puncture. The puncture should be made in the fourth or fifth interspace. The first two drops of spinal fluid should be kept for examination, as the protein content of the spinal fluid is extremely important. The protein is normally from 40 to 50 mg. per cent; anything above that is abnormal and when present an intraspinous injection of lipiodol followed by roentgenography should be made to determine any encroachment upon the spinal canal. Five cubic centimeters of the lipiodol is introduced with the patient in the prone position on the fluoroscopic table and x-ray examination made in this position. The characteristic deformity shows encroachment upon the shadow produced by the lipiodol opposite the intervertebral disc. Mixter had 21 unoperated cases with negative lipiodol findings and 58 cases which were operated upon. In each instance there was a protrusion in the canal of the intervertebral disc. The operation which is done consists of a hemilaminectomy, usually removing the lamina involved and a portion of the lamina above and below. Occasionally it is necessary to resect the articular facet. The protrusion is removed, occasionally transdurally. Because of the back injury, and also because of the laminectomy, a fusion of the spine is usually done. In his cases a rupture occurred between the second and third lumbar in 1; between the third and fourth in 4; between the fourth and fifth in 35, or 60 per cent; between the fifth lumbar and first sacral in 17, or 30 per cent; and between the first and second sacral in 1. Of these patients 32 are well, 13 improved, 3 unimproved, 1 died of the operation, another died of urinary sepsis following the operation without any improvement, and 8 which have been observed from one to six months were too recent to evaluate. Seven have been operated upon with no evidence of rupture. There were 3 of these who had a localized arachnoiditis and the other findings were normal. The paper was discussed by **Dr. Kellogg Speed** (Chicago) who stated that he had had 100 patients with sciatica following trauma, and of this group 5 continued to have symptoms in spite of conservative orthopedic measures. Three of these were given a lipiodol injection and in all there were the characteristic deformities shown by Mixter. Speed advocates the use of simpler measures before resorting to lipiodol. **Dr. Howard Naffziger** (San Francisco) stated that many of these cases were previously operated upon for cord tumors. He has had 30 proved cases and states that many of these patients have repeated slight injuries, such as horseback riding or jumping. In many cases it is necessary to open the dura in order to determine the presence of a mass.

Dr. Owen H. Wangensteen (Minneapolis) presented **Studies on the Etiology of Acute Appendicitis.** The anatomy of the appendix was studied in over 800 specimens, and the Gerlach fold was found to be present in 80 per cent. In no instance was there any evidence of sphincter except in the fetus. The distensibility of the normal human appendix was 40 cm. of water; that of the appendix removed between attacks was 50 cm. of water; whereas that with acute suppurative appendicitis was 70 and above. In patients with appendicostomy it was found that similar pressures existed. In order to determine the bacterial influence in appendicitis, exudate from patients with acute suppurative appendicitis was introduced

into the appendix exposed in appendicostomy and in no instance did an infection occur. The appendix of a patient with an appendicostomy was cannulated and it was found that from 1 c.c. to 2 c.c. were secreted in twenty-four hours. In investigating a large number of animals, it was found that the rabbit's appendix was similar to that of a human. It secretes 0.02 c.c. per minute and if the base of it is tied it will perforate in from ten to fourteen hours. If crotin oil is given by mouth or hypertonic solution intravenously, the perforation occurs much earlier, in from three to six hours. These effects do not occur if the arteries of the appendix are blocked. The volumetric content of the human appendix is from 0.1 to 0.2 c.c.

Dr. E. P. Lehman (University, Va.) discussed **The Place of Exploratory Operation in the Surgery of Subphrenic Abscess.** He has had 9 cases of subphrenic abscess which were explored and no abscess found. There were 20 cases in which an abscess was found, giving a correct diagnosis of 51.7 per cent. Five cases which were missed clinically were found at autopsy or in some other way. In the cases operated upon in which abscesses were found, there is a mortality rate of 23 per cent. Aspiration is condemned as a diagnostic procedure, because it is dangerous and also unreliable. The mortality rate in the cases which were explored and the abscess not found was 55.5 per cent. All of these, however, died of other conditions: 2 of multiple liver abscesses, 1 of empyema, 1 of a pulmonary embolism, and 1 of an undetermined sepsis. The extraserous approach is perfectly safe and exploratory operation is justified if a diagnosis cannot be made otherwise.

In discussion, **Dr. Alton Ochsner** (New Orleans) emphasized the importance of early diagnosis and exploration if diagnosis cannot be made and emphasized the importance of the extraserous approach because of its relative safety and lower mortality.

Dr. Howard Lilienthal (New York) advised, in these cases in which the diagnosis is difficult, the production of a pneumoperitoneum before the taking of an x-ray. **Dr. Edwin Beer** (New York) suggested in those cases in which there is a difficulty of diagnosis that a perirenal insufflation of air or carbon dioxide be made.

REVIEW OF THE FIFTIETH ANNIVERSARY MEETING OF THE AMERICAN ORTHOPAEDIC ASSOCIATION, LINCOLN AND OMAHA, NEB., JUNE 2 TO 4, 1937

WALLACE H. COLE, M.D., ST. PAUL, MINN.

(From the Division of Orthopaedics of the Department of Surgery, University of Minnesota Medical School)

THE Fiftieth Anniversary meeting of the American Orthopaedic Association was held in Lincoln and Omaha, Neb., June second to fourth of this year. The major contributions were:

Dr. R. Plato Schwartz, Rochester, N. Y., outlined the requirements for a subastragalar arthrodesis and advocated a lateral J-shaped incision for complete

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exposure of the joints to be arthrodesed. The amount of bone to be removed and its location are to be determined by carefully made preoperative x-rays.

Dr. Isadore Zadek, New York City: Dr. Zadek stated that acute osteomyelitis in the adult is very rare with no literature on the subject. He reported nine cases. "Acute" is rather a misleading word, since onset is slow and frequently follows earlier injury. Symptoms are localized pain with no fever or only slight rise in temperature. Leucocytosis is present only if there is fever. X-rays are negative for several weeks or months and then localized; irregular mottling of the bone is seen. Pathologically there is central granulation tissue and pus, more often in the shaft than in the end of the long bone, without subperiosteal involvement in most cases, the disease spreading along the medulla. Sequestrum formation is rare. Treatment is operative and consists of decompression by removal of small window of bone over diseased area.

Dr. R. E. Robertson, Toronto, reviewed treatment of acute staphylococcic osteomyelitis as a clinical entity in the light of recent serologic findings. Clinical experiments and observations showed titer could be raised five to fourteen times by use of toxoid; this should be used as a preventive measure in children with staphylococcal skin infections, etc. Acute cases of infection must not receive toxoid until later, however. Operative treatment should be used only in those cases of osteomyelitis with abscess present, as there is no indication otherwise. Titer must be raised before operating a Brodies abscess, especially in elderly individuals.

In discussion, **Dr. H. Winnet Orr,** Lincoln, Neb., showed several excellent results in osteomyelitis treated by his method with vaseline packs and immobilization in plaster.

Professor Lelio Zeno, Rosario de Santa Fe, Argentine, discussed his treatment of burns and showed moving pictures of the method. Burns, like fractures, are a condition and not a disease and are benefited by immediate immobilization in plaster of Paris in both children and adults. Pain is suppressed almost instantly and infection prevented. Plasters wet with cold water are applied directly to burned areas with limbs in good position after evacuating blisters if they are very large or tense. These plasters are not changed for at least ten days in first and second degree burns. Leg plasters are supported on Braun splints and arms are suspended from overhead frame. Bed clothes are supported by cradles to allow free ventilation.

Dr. Leo Mayer, New York City, stated his opinion that the secret of proper treatment in slipping of the femoral epiphysis is early diagnosis. Such diagnosis should be made on a history of slight limp with limitation of internal rotation and on radiographs showing loss of normal bulge of head superiorly, prominence of superior lip of neck at epiphyseal line, and apparent diminution in the length of the epiphysis. Treatment: drilling of epipyseal line through trochanter in seven or eight places with plaster of Paris immobilization for two to three months.

Symposium—Fractures of the Neck of the Femur: Dr. Guy W. Leadbetter, Washington, D. C., stated that fifty-nine cases followed showed 71 per cent union with an additional 6 per cent good functional results without union by nonoperative treatment. Conservative treatment should be applied when possible and should be the method used in teaching although internal fixation is more adequate. A recent series shows 75 per cent operative and 25 per cent conservative. Use of heel-palm test for reduction was emphasized.

Dr. R. T. Harris, Toronto, pointed out that internal fixation has been used for three years at the Toronto General Hospital. The Smith-Peterson nail is used, and he feels that "unsolved fracture" is nearly conquered. The principles of treatment are: (1) accurate reduction; (2) close approximation of fragments; and (3) maintenance of approximation. Failures are due to: (1) nail in poor position; (2) too early weight bearing, eight weeks being minimum time.

Dr. W. W. Plummer, Buffalo, uses Smith-Peterson nail with elaborate technique and a frame that clamps to table. He feels pain is relieved early and the fear of long fixation in plaster of Paris is eliminated.

Dr. E. G. Brackett, Boston, in discussing reconstruction operations for ununited fractures of the neck of the femur, divided methods into two groups: (1) where articular structures remain intact and can be used (Brackett); (2) where non-articular structures are used. Procedure must be chosen on basis of what will stand up to expected use.

Discussion of the symposium showed the Smith-Peterson nail to be the most popular method of internal fixation. **Orr** felt that there was a tendency to minimize dangers of operation and demonstrated cases treated with moleskin traction and double leg plaster with excellent results. **Henderson** advocated use of lag-screw and showed slides of perfect results. **Albee** showed advantages of his reconstruction operation from viewpoint of comparative anatomy with the advantage of long abductor lever. **Dickson** said the Brackett operation was the best of all reconstruction operations but that fixation must be used for three to five months.

Dr. Robert Funsten, Charlottesville, Va., reported twenty cases of so-called "dash-board" dislocations of the hip occurring in passengers in the front seat of an automobile with head-on collisions and due to force exerted on flexed and adducted femur. Treatment: immediate reduction with traction or plaster for six to eight weeks; no weight bearing for three months. Prognosis good in uncomplicated dislocation, but with fracture of posterior lip of acetabulum some disability remains.

Mr. R. Watson Jones, Liverpool, England, spoke by invitation, on the development of fracture treatment in Great Britain. General standards have been low, but fracture clinics are being started so that now about one-fourth of the cases are treated by experts. The basis of the new development is a threefold program: (1) establishment of fracture units in the hospitals; (2) better teaching of the medical students and postgraduates; (3) the formation of a network of industrial rehabilitation centers which consider both the physical and mental side of the problem. "Malingerers are made and not born." A motion picture film to show old and new methods of fracture treatment is used as an educational method. This was exhibited.

Dr. Svante Orell, Stockholm, Sweden, described three types of bone used for surgical bone grafting which complement but do not supplant live autogenous grafts: (1) "Os purum," bone which has been cleaned of cellular elements by treatment in salt solution, potassium hydroxide, and acetone, and which is used to fill in gaps after resection, since it can be cut to exact shape and since its porous nature allows osseous and connective tissue cells to penetrate easily. (2) "Os novum," new bone formed on and in a piece of os purum, transplanted sub-

periosteally on the tibia and removed in one to two months. Used for spine fusions and pseudarthrosis. (3) "Boiled bone," osteomyelitic or sarcomatous bone boiled and immediately replaced to fill gap left by its removal.

Dr. Paul Swett, Hartford, Conn., spoke on synovectomy used to preserve joint surfaces and to remove disease synovial membrane. It is indicated in: (1) certain cases of atrophic arthritis; (2) chronic traumatic arthritis; (3) benign tumors of synovial membrane; (4) syphilitic arthritis; (5) intermittent hydrops; (6) chronic ossifying synovitis. It is not indicated in hypertrophic or tuberculous arthritis.

SIXTY-THIRD ANNUAL MEETING OF THE AMERICAN NEUROLOGICAL ASSOCIATION, ATLANTIC CITY, JUNE 3 TO 5, 1937

WILDER PENFIELD, M.D., AND JOSEPH EVANS, M.D., MONTREAL, QUEBEC

WHAT is the limit of tolerance of the brain for radiotherapy? This question was answered in part by **Percival Bailey, J. O'Connell,** and **A. Brunschwig** in a paper entitled **Experiences with the Roentgen Treatment of Cerebral Gliomas.** The authors described the results of treatment of two cases of glioblastoma and one of medulloblastoma. The first two patients received 1,500 r. units and 1,800 r. units; the third, a child, received 1,300 r. units, in divided doses. The dosage was great enough to produce a weeping edema of the scalp. Subsequent to treatment all signs of tumor disappeared, but at the end of about eighteen months all three patients became progressively weak and asthenic until death occurred.

Postmortem histologic study of the brains showed no sign of tumor remaining, but it also showed extensive damage to neurones. There was loss of Nissl substance in ganglion cells, appearance of intracellular fat, and fragmentation of neurofibrillae. The glial cells were also markedly affected: swelling of oligodendroglia, clasmatodendrosis of astrocytes, hypertrophy of microglia, and active phagocytosis within the brain. The meninges and blood vessels of the brain showed little change. The pituitary body was unaltered.

The authors believe that since such a highly destructive effect can be achieved through the intact skull, there is no indication for direct roentgen treatment of brain tumors through a craniotomy opening at operation as practised in the neurosurgical clinics of Sachs and of Elsberg.

The consensus of opinion among the discussors was that somewhere a middle ground will be found so that neoplastic cells may be destroyed and cerebral tissue preserved. To achieve such a therapeutic effect is, of course, the ambition of all radiotherapeutists. The upper limit of x-ray dosage at least is clearly described by the authors.

Peet and List reported a study of facial sweating in patients who had been submitted to varying types of sympathetic and trigeminal neurotomy. Although after sympathectomy sweating in the face disappears when the patient is hot, there occurs increased sweating as the result of gustatory-salivary reflex. This reflex produces sweating in the face when sour substances are taken into the mouth.

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Hyperactivity of the sweat glands was found also after sympathectomy when acetylcholine was injected. This suggests that sweating, which is to be listed as a parasympathetic activity, has a peripheral apparatus which is hypersensitized to humoral stimulation by section of its nerve connection with the central nervous system. This finding is in conformity with the discovery by James White and his coworkers that postganglionic sympathectomy hypersensitizes the peripheral blood vessels to the activity of adrenalin circulating in the blood.

Thus it may be assumed that section of the autonomic outflow from the cord cuts the parasympathetic fibers to the sweat glands in the face and sympathetic fibers to the vessels producing sensitization of each to its own particular humoral stimulant. This is another example of the activation of the autonomic function by humoral as well as neural stimulation.

Sachs, Schwartz, and Weddell presented evidence that taste fibers from the anterior two-thirds of the tongue sometimes traveled to the facial nerve by way of the greater superficial petrosal nerve, instead of invariably through the chorda tympani to the facial nerve as ordinarily believed. The evidence was derived from the study of patients with section of the chorda tympani during radical mastoidectomy as compared with the results of section of the greater superficial petrosal during trigeminal rhizotomy.

Penfield and Boldrey made an analysis of the motor and somatic sensory representation in the cerebral cortex of man from evidence obtained during stimulation of the cortex in a search for epileptogenic foci.

Schwab and Tureen pointed out that the spinal cord might recover after fifteen minutes of ischemia but that longer periods of arrest of circulation were invariably fatal to the cord. The anterior horn cells were more vulnerable than other neurones.

There is a frequently recurring tendency to make elaborate laboratory or mathematical studies replace simple clinical thinking. A typical example of this tendency was a paper by **Savitsky and Kessler** urging the adoption of the Ayala index in cerebrospinal fluid studies. By comparing the spinal fluid pressure before and after withdrawal of 10 c.c. of fluid, the index expresses mathematically the fact that the withdrawal has been made from a larger or smaller total volume of fluid. The use of the Ayala index substitutes a figure for simple thinking. But one is forced to ask, why clothe a mathematical formula with authority?

Wolff and Graham in a communication, summarized but not read, concluded from a study of certain cases of migraine that the pain may be relieved by ergotamine tartrate because this drug causes constriction of the cranial (not the cerebral) arteries. They pointed out also that the pain might be stopped by shutting off the temporal or the external carotid arteries and that distention of the temporal artery by saline at operation produced the pain. The conclusion might seem to be that if relief from ergotamine proved to be too transient, surgical arterial ligation might be undertaken, but the authors did not offer this conclusion.

The session was opened by a scholarly symposium on electrical studies of fundamental nervous processes by the neurophysiologists **Bronk, Gasser, Lorente de No, and Bishop.** The electrical phenomena described in neurone and synapse

are of interest, but the time for the application of this new knowledge to clinical neurology or neurosurgery has not yet come. It may therefore be ignored in a report such as this. For the same reason the majority of the papers presented have not been discussed here. Selection of a few papers for this report has been made on the basis of what seemed to have surgical application, although the element of personal interest and the recurring lure of Atlantic City's ocean breeze may also have determined the selection to some extent.

REVIEW OF THE THIRTEENTH SCIENTIFIC MEETINGS OF THE AMERICAN HEART ASSOCIATION

FREDERICK R. MAUTZ, M.D., CLEVELAND, OHIO

The American Heart Association held its thirteenth scientific meetings in Atlantic City, N. J., on June 7 and 8, 1937. Following are abstracts of the subjects of particular interest to the surgeon:

Observations on Phlebitis, Dr. Edward A. Edwards, Boston: Experimental observations were presented demonstrating how complete venous thrombosis causes thickening and distortion of the valves. Incomplete thrombosis is especially likely to occur at the valve sites. The result is that the originally thin and flexible valves are converted into thick, inelastic structures with associated functional disturbances of stenosis and regurgitation. It was pointed out that in clinically recognizable phlebitis relatively early exercise is not dangerous and that excessive immobility of the affected part may lead to a "stagnation clot" above the zone of phlebitis; and since this clot may not be as firmly attached to the vein wall as the thrombus in the zone of more severe inflammation, there may be greater danger of pulmonary embolism. If pulmonary infarction occurs, ligation of the main venous trunk above the site of the phlebitis was advised. In varicose phlebitis ligation of the main venous trunk plus small injections of sclerosing agents was advised.

In the discussion **Dr. Alton Ochsner,** New Orleans, referred to Dr. Bancroft's recent work showing that about 12 per cent of postoperative patients show an increasing clotting tendency with evidence that low protein high carbohydrate diet plus intravenous sodium thiosulphate reduces the clotting tendency. Dr. Ochsner advocated the use of leeches in phlebitis. He stated that they shorten convalescence, the probable mechanism being by the local and systemic action of hirudin. It was also pointed out that intravenous heparin has been recommended postoperatively to eliminate postoperative thrombosis and embolism.

The Treatment of Scleroderma by Mecholyl Iontophoresis, Dr. A. Wilbur Duryee and Dr. Irving S. Wright, New York City: Thirty-four cases diagnosed as scleroderma were included in the series. There were 8 males, 26 females. The average age was 37.5 years. In 32 there was a definite Raynaud's syndrome. The treatment consisted of the local application of mecholyl in asbestos dressings over the affected parts and the passage of an electric current of 20 ma. between a positive electrode placed over the dressing and a negative electrode

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placed over the back. Treatments for 20 to 30 minutes were given two to three times per week. Local hyperemia persists 4 to 8 hours after treatment, indicating local absorption.

There was definite improvement in symptoms, greater degree of motion of fingers, and definite softening of the skin. Fifty treatments were considered adequate to produce a maximum degree of improvement, but improvement was seen with fewer treatments. Of 27 cases considered to have been adequately treated, 16 showed definite improvement and 11 showed slight or no improvement. These results were believed to be better than those following sympathectomy or parathyroidectomy. There was no evidence of coronary artery sclerosis following the use of mecholyl. Intravenous or subcutaneous administration was believed to be dangerous. Of the group treated, there was one case of skin hypersensitiveness to mecholyl.

In the discussion **Dr. Edward V. Allen** said that the results of this report are more encouraging than the results of operation. He also pointed out the development of coronary artery sclerosis in animals by the administration of mecholyl.

The Pathologic Basis for Intermittent Claudication in Arteriosclerosis, Dr. J. Ross Veal, New Orleans: Forty-one cases of arteriosclerosis with intermittent claudication were studied by the method of vasography. These patients complained of bilateral pain in calf muscles after walking one to two blocks and they obtained relief after 1.5 to 15 minutes' rest. The average age of the group was 51.4 years. The arteriography was done with the patient at a basal state.

In comparing the results of this study with the normal arteriogram, three groups were recognized: Group 1—21 cases showed complete obstruction of one or more main arterial trunks. Group 2—6 cases showed narrowing but not complete obstruction of main arteries. Group 3—14 cases showed large arteries to be patent and of normal size with defects in the small muscular branches. All the patients showed failure of visualization of the small muscular branches and their arborization as seen in normal cases.

There was no direct correlation between the size of the artery occluded and symptoms. The most marked symptoms were present when abundant collateral channels failed to appear.

Symptoms were believed to be due to relative ischemia, depletion of the nutrient substances in the tissue fluids, and acute starvation of the muscle following activity. Oxygen studies showed no decrease in the oxygen saturation of the arterial blood during exercise. The possibility of a metabolic pain factor, as suggested by Lewis, was believed logical.

Experiences With the Conservative Management of Acute Arterial Occlusion, Dr. Louis G. Herrmann, Cincinnati: The report dealt with 53 cases of acute arterial occlusion, 44 thromboembolic and 9 ligations. No cases of aneurysm or Buerger's disease were included. It was pointed out that an accurate differential diagnosis between thrombosis and embolism was sometimes difficult. The importance of early diagnosis and early institution of therapy was emphasized. Pain was an early symptom in only 50 per cent of the cases; numbness, coldness, and paresthesia were other early signs. Absent pulse, lowered skin temperature, pallor, sensory disturbances, and impairment of function characterized the extremity following acute arterial occlusion.

The results of acute arterial occlusion depend upon the amount of available collateral circulation. Peripheral angiospasm was believed to develop and reduce the amount of collateral blood supply. The importance of medical treatment during the first 24 hours was emphasized. This consisted of local warmth, care being taken not to cause burns, whiskey, intravenous papaverine hydrochloride as a vasodilator, and intravenous sodium thiosulphate as anticoagulant. Early therapy of pressure and suction is believed to be of value if a pink color can be maintained; late treatment may be dangerous if indications for amputations are not recognized. In cases which recover with this type of treatment, "ischemic neuritis" may be very disabling. Conservative treatment does not restore as good a circulation as successful embolectomy, but the satisfactory results following embolectomy were not believed to be striking enough to warrant the frequent employment of this procedure.

Hypertension Produced by Constriction of the Renal Artery in Sympathectomized Dogs, Dr. Norman E. Freeman, Philadelphia, **and Dr. Irvine H. Page,** New York City: In a series of six dogs, three-stage thoracoabdominal sympathectomy was done preliminary to producing renal ischemia by the Goldblatt method. Hypertension resulted in every experiment in spite of the sympathectomy. One animal was found with spontaneous hypertension. In this animal sympathectomy caused a fall in mean arterial pressure; later, renal ischemia was produced and hypertension resulted. In a second series of four animals, cardiac denervation was done in two stages previous to producing renal ischemia and again the hypertension developed after production of renal ischemia, indicating that reflex control of the cardiac output played no rôle in the hypertension. It was also believed that there was no increased adrenalin secretion. Blood volume determinations on normal and hypertensive dogs showed no difference. It was pointed out that complete proof that the sympathetic nervous system played a part would require that the outlying ganglia be removed in addition to the main trunks and ganglia.

In the discussion **Dr. Harry Goldblatt** pointed out that the studies in experimental hypertension do not completely rule out the possibility that sympathectomy may lead to improvement in human cases. The early phenomena may be of a reversible nature, which cannot be the case in renal ischemia produced by a silver clamp.

The Physiologic Effects of Extensive Sympathectomy for Essential Hypertension, Dr. Edgar Van N. Allen and Dr. A. W. Adson, Rochester, Minn.: In cases of essential hypertension believed to be of vasomotor origin but resistant to medical treatment, these authors have been doing bilateral two-stage thoracolumbar sympathectomy, plus removal of adrenal tissue in some cases. Patients were selected on basis of response to (1) vasodilators, (2) chilling extremities, (3) sodium penotol, (4) rest and sleep. The following postoperative effects were noted: (1) fall in blood pressure, (2) orthostatic tachycardia which gradually disappeared in time, (3) diminution in response to cold test in favorable cases, (4) diminished sweating of lower torso and legs, (5) postural changes in blood pressure, (6) slight lowering of basal metabolic rate, (7) improvement in renal function and eyegrounds in some cases, (8) no impaired motor function, (9) mild diarrhea in a few cases, (10) relief from dysmenorrhea. Forty-five patients were operated on from January, 1935, to February, 1937. Of these there were no operative fatalities. The present status is: 20 failures, 13 fair results from 3 to 18 months, 11 good results from 3 to 23 months.

Some Problems in the Diagnosis, Prognosis, and Treatment of Acute Arterial Occlusion, Dr. Harold E. Rykert and Dr. Duncan Graham, Toronto: In the diagnosis, two types of pain were recognized: (1) Early severe sharp pain at the level of the arterial occlusion believed to be due to arterial spasm at the site of embolic occlusion. This type of pain is absent in thrombosis. (2) Later dull pain distal to the point of arterial occlusion due to ischemia. Spasm was believed also to affect collaterals. In 10 consecutive cases of occlusion of main arteries of the lower extremity, 5 responded to conservative treatment, and in 5 cases this treatment was ineffectual. There was spontaneous recovery in 7 out of 12 cases involving the upper extremity. Conclusions: (1) Primary disease is most important factor in determining the outcome. (2) Early treatment with pressure-suction and antispasmodics and heat to the body is of value. (3) Embolectomy is rarely indicated.

The Diagnosis and Treatment of Chronic Constrictive Pericarditis, Dr. Paul D. White, Boston. Dr. White introduced a patient, O. W. P., a physicist who had suffered from the disease. Mr. P. described his symptoms, characteristic of chronic cardiac compression, and said that he was much improved following the decompression operation, which was performed by Dr. Churchill.

Acute and Chronic Compression of the Heart, Dr. Claude S. Beck, Cleveland: The pathologic physiology of cardiac compression, acute and chronic, was demonstrated by motion pictures. The rise in venous pressure and fall in mean arterial pressure, diminution of pulse pressure with compression of the heart by pericardial hemorrhage, purulent pericarditis, pericardial effusion, pericardial and epicardial scar, localized or generalized, or combinations of the above, the enlargement of the liver, formation of ascites, hydrothorax with marked rise in venous pressure, as high as 42 cm. of water in the chronic form of cardiac compression were demonstrated. The operative technique was shown in two cases. A group of several patients were shown preoperatively and postoperatively, all with marked improvement. It was pointed out that the heart never hypertrophies and that it may undergo "disuse atrophy" as a result of chronic compression. Two triads were discussed. The triad for acute compression consists of (1) high venous pressure, (2) low arterial pressure, and (3) small quiet heart. The triad for chronic compression consists of (1) high venous pressure in the arm, (2) ascites, and (3) small quiet heart.

REPORT OF PROCEEDINGS OF THE AMERICAN ASSOCIATION OF GENITO-URINARY SURGEONS, JUNE 14, 15, AND 16, 1937

CLYDE DEMING, M.D., NEW HAVEN, CONN.

(From the Division of Urology of the Department of Surgery, Yale University School of Medicine)

Tumors of the Adrenal Cortex, Dr. A. J. Scholl, Los Angeles: This was an excellent paper, giving the experience with two cases of adrenal tumors which were diagnosed by air injection and palpable mass. The patients were operated upon. One died in thirty-six hours of extremely low blood pressure although she had had extensive treatment by intravenous methods of calcium chloride.

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Autopsy showed an absence of the adrenal on the other side. The other patient lived longer, but the cause of death was the same. Interesting exposure of the adrenal tumor was made by placing the patient in the procumbent position with a depressed head and flexion of the trunk at the hips. The special point at issue was the likelihood of the absence of one adrenal.

Squamous Cell Carcinoma of the Kidney Pelvis, Dr. Charles C. Higgins, Cleveland: Sixty-five cases are now reported. The causes are leucoplakia, chronic inflammation, and deficiency in vitamin A. Males and females are equally involved. The urinary symptoms were those of frequency of urination, pain in the back, dysuria in 70 per cent, and general malaise over some period of time. The prognosis is grave. No case lived longer than five years.

Three Unusual Primary Malignant Tumors of the Kidney, Dr. Frank S. Patch, Montreal: Unusual malignant tumors of the kidney are reported.

Tumors of the Renal Pelvis and Ureter, Dr. John R. Caulk, St. Louis: Tumors of the renal pelvis and ureter form 5 to 10 per cent of all renal tumors. Eighty per cent of tumors of the renal pelvis are papillary; 60 per cent invade the kidney pelvis and ureter. Transplants do not take place unless there is a break in the mucous membrane. The disease is probably a generalized one of the mucous membrane. Treatment should include excision of the ureter as well as the kidney.

Dr. MacKenzie reported an unusual case of neurocytoma of the kidney in which massage of the left adrenal caused no change in blood pressure, but massage of the right adrenal raised the blood pressure one hundred points. Fifty cases are reported in the literature.

Dr. Cahill discussed the paper, reporting one hundred cases of air injection of the perirenal tissues without accident. Only one-fourth of the cases may be diagnosed by this method. Patients with suprarenal tumors have both male and female hormones in the urine. The female may show fifteen times as much male hormone in the urine as is shown in the normal male urine. Some may not have any female or male hormone.

Supernumerary Kidney, Dr. Joseph F. Geisinger, Richmond: Dr. Geisinger reports two cases of supernumerary kidney from autopsy. Thirty-eight cases are reported. The small kidney was found above and medial to the normal kidney, the supernumerary kidney having its own blood supply and ureter.

Clinical and Radiologic Data With Congenital and Acquired Single Kidney, Dr. William F. Braasch and Dr. J. W. Merricks, Rochester, Minn. (by invitation): Sixty-eight cases of congenital and acquired single kidney are reported. The male and female are equal in number. A congenital, solitary kidney shows asymmetry to the trigone. The right is more frequently absent than the left. The psoas muscle is less distinct and wider in adenesia (absence of one kidney). The outline of the solitary kidney is larger than normal; its pelvis is larger; its function is faster with intravenous test. Scoliosis is present in the direction of the absent side.

The Problem of the Solitary Diseased Kidney, Dr. William E. Lower, Cleveland: Dr. Lower stressed conservatism in the treatment of diseases of a single kidney, especially advising drainage of the kidney during the acute phases of infection or after the removal of calculus.

The Ectopic Kidney. Surgical Aspects in a Series of Ectopic Kidneys, Dr. David W. MacKenzie and Dr. Allen B. Hawthorne, Montreal (by invitation): A review of the literature was made, giving the various types of ectopic kidneys: unilateral, bilateral, and crossed ectopic kidneys. Male and female are equally involved. Treatment depends upon the pathology.

A Further Report on the Relationship of Papillary Lesions to Renal Calculus, Dr. Alexander Randall, Philadelphia: Bases for stone formation: (1) Begin on papilla; (2) have attachment to papilla; (3) originate in minor calix; (4) initiatory lesion found; (5) initiatory lesion found in papilla; (6) deposit of calcium within the distal tubules; (7) calcium plaque observed at autopsies; (8) forty-one of such examples found; (9) calcium plaque found chemically to yield calcium and nucleate; (10) pure calcium phosphate and oxalate occur on the basement membrane of the tubules; in 609 autopsies calcium plaques were found in 2.9 per cent.

Experimental work: Avitaminosis in rats gives ulcer of the papilla. Rabbits' kidneys secrete and concentrate toxins injected into the blood stream. The distal tubules are most greatly involved in this toxic experiment. Parathyroid hormone injection in dog has given one calcium plaque on the papilla.

Impression to date with regard to stone formation is that there must be an initiatory ulcerative lesion on which forms a calcium plaque.

Spontaneous Reno-Intestinal Fistula. Report of Two Cases, Dr. Miley B. Wesson, San Francisco: Two cases reported; one case operated upon died; second case not operated upon. Both probably had perirenal abscesses.

Roentgenological Examination of the Kidney With Special Reference to Injuries Associated With Retrograde Pyelography, Dr. William E. Stevens, San Francisco: Dr. Stevens demonstrated that it is difficult to pass a catheter or bougie through a normal ureteral or kidney pelvic wall. If these structures are penetrated by ureteral instruments, the wall is usually pathologic.

Malignancy of the Bladder Occurring in a Hunner Ulcer, Dr. Francis R. Hagner, Washington, D. C.: Malignancy of bladder occurring in a Hunner ulcer eleven years after initiatory lesions proved by histologic sections; recovery.

Experiences With High Voltage Deep Therapy in the Treatment of Malignant Tumors of the Urinary Bladder, Dr. Roger C. Graves and Dr. Richard Dresser, Boston (by invitation): The use of high voltage machines 200 K.V. for carcinoma of the bladder has given gross evidence of regression of the tumor. Sixteen to eighteen hundred units given. Twenty-four cases treated. Supervoltage treatment gives but few cures. Combined treatment with surgery is advised.

Radio Therapy of Bladder Carcinoma: Five-Year Results—Failures—Future Therapy, Dr. Benjamin S. Barringer, New York City: Surgery gives 25 per cent five-year cures; radiation, 34 per cent five-year cures. However, serious complications due to infections of the kidneys occur. The treatment with 800 to 1,000 K.V. is discouraging. Supervoltage treatment gives somewhat deeper penetration and more regression of the tumor but not necessarily more cures.

A Report After Ten Years of a Series of Bladder Tumors Treated by Suprapubic Radon Implantation, Dr. Edward L. Keyes, New York City: Thirty-one cases reported. One postoperative death. Recurrences controlled by radon seeds. Ten of the thirty-one cases were tumors of Grades I and II.

Successful Radical Perineal Resection of the Bladder Neck for Carcinoma, Dr. Clyde L. Deming, New Haven, Conn.: Hugh Young's radical operation for carcinoma of the prostate applied to bladder neck cancer with a six-year cure with full control of urination and a normal bladder capacity. A new procedure.

Methods of Selecting the Proper Operative Treatment for Cancer of the Bladder, Dr. Hugh Cabot and Dr. John M. Pace, Rochester (by invitation): Methods used for this work were cystograms, pyelograms, and biopsies. Errors in diagnosis lay within the field of faulty estimation of the position of the tumor and its extension and lack of full appreciation of the renal complications.

Human Prostatic Infection With Brucella Abortus (Alcaligenes Abortus), Dr. Montague L. Boyd, Atlanta, Ga.: Report of a case of human prostatic infection with *Brucella abortus* proved by culture.

Modern Plastic Perineal Prostatectomy—Its Indications and Advantages, Dr. Frank Hinman, San Francisco: Dr. Hinman reported twenty-five cases with completely closed perineum, after fully controlling the hemorrhage at the bladder neck by closing the prostatic cavity. He now, however, uses a wick drainage in the perineum rather than tight closure of the skin. This wick drain prevents abscess formation in the operative field. Care must be taken to obtain complete hemostasis. Average postoperative period is sixteen days for twenty-five cases. The technique presented with slides and movies. The advantage of perineal prostatectomy is the removal of carcinoma originating within the hypertrophy, which occurs in 10 to 14 per cent of the cases.

Prostates in Women, Dr. Hugh H. Young, Baltimore: Dr. Young reported three cases of supposed females who were, in actual fact, proved to have prostatic tissue around the urethra, although they were pseudohermaphrodites, who had external genitalia of the female and an ovary on one side and a testis on the other.

Prostigmin in the Treatment of Ureteral Calculi, Dr. Benjamin H. Hager, Los Angeles: Read by title. Discussion by Dr. O'Crowley, who stated that a drug allied to prostigmin called "No. 568" made by Sharp and Dohme acts better than prostigmin. Two cubic centimeters of this drug given intramuscularly has given remarkable results in seventeen cases. The drug must be given intramuscularly and the areas must be massaged for three or four minutes, as it causes a little smarting. This, however, is not significant.

Plastic Operations on the Ureter, Dr. E. Granville Crabtree, Boston: (a) For the Relief of Megaloureter Due to Congenital Deformity of the Lower Ureter.—Four cases. The ureter was cut longitudinally and a definite strip removed, decreasing the caliber. Care should be taken not to lift the ureter from its bed, as the attachments to the bed aid in the blood supply. Satisfactory results were obtained in two cases.

(b) For the Relief of the Short Congenital Ureteral Stricture at the Ureteropelvic Junction.—Correction of a tight exit of the kidney pelvis was made by opening the pelvis, drawing the tightened area upward within the pelvis, and slitting it but not severing it longitudinally, allowing the excess ureter to remain within the pelvis. Two cases with good results shown.

Recent Experiences With Ureteroenterostomy, Dr. George Gilbert Smith, Boston: Two types of operation given: One, Coffey No. 2; and second, a group

of cases where the ureter was transplanted after the Wetzel method of a gastrostomy. The latter method would seem superior to the former. Twenty-four cases reported. Sixteen such were carcinoma of the bladder. Not a very great risk with the Wetzel method in selected cases.

Obliteration of the Ureter in a Congenital Kidney With Hydronephrosis, Dr. David W. MacKenzie and Dr. Magnus I. Seng., Montreal (by invitation): Interesting report of a nephrectomy case in which a second ureter from the pelvis ended blindly downward and a ureter from the bladder ended blindly upward, there being a segment missing. The remainder of the kidney was hydronephrotic.

The Value of Hexamethylenamin and Mercurochrome Intravenously in Urology, Dr. George R. Livermore, Memphis, Tenn.: The continued use of these drugs is shown to be applicable to a certain group of cases. Small doses should be given frequently.

Tumors of the Spermatic Cord, Dr. William C. Quinby, Boston: Few tumors and hydroceles reported. **Retroperitoneal Papilliferous Cyst-Adenocarcinoma. Report of a Case, Dr. Thomas P. Shupe,** Cleveland: Report of a single case. **Melanoblastoma of the Penile Urethra, Dr. Charles M. McKenna,** Chicago: Single case report.